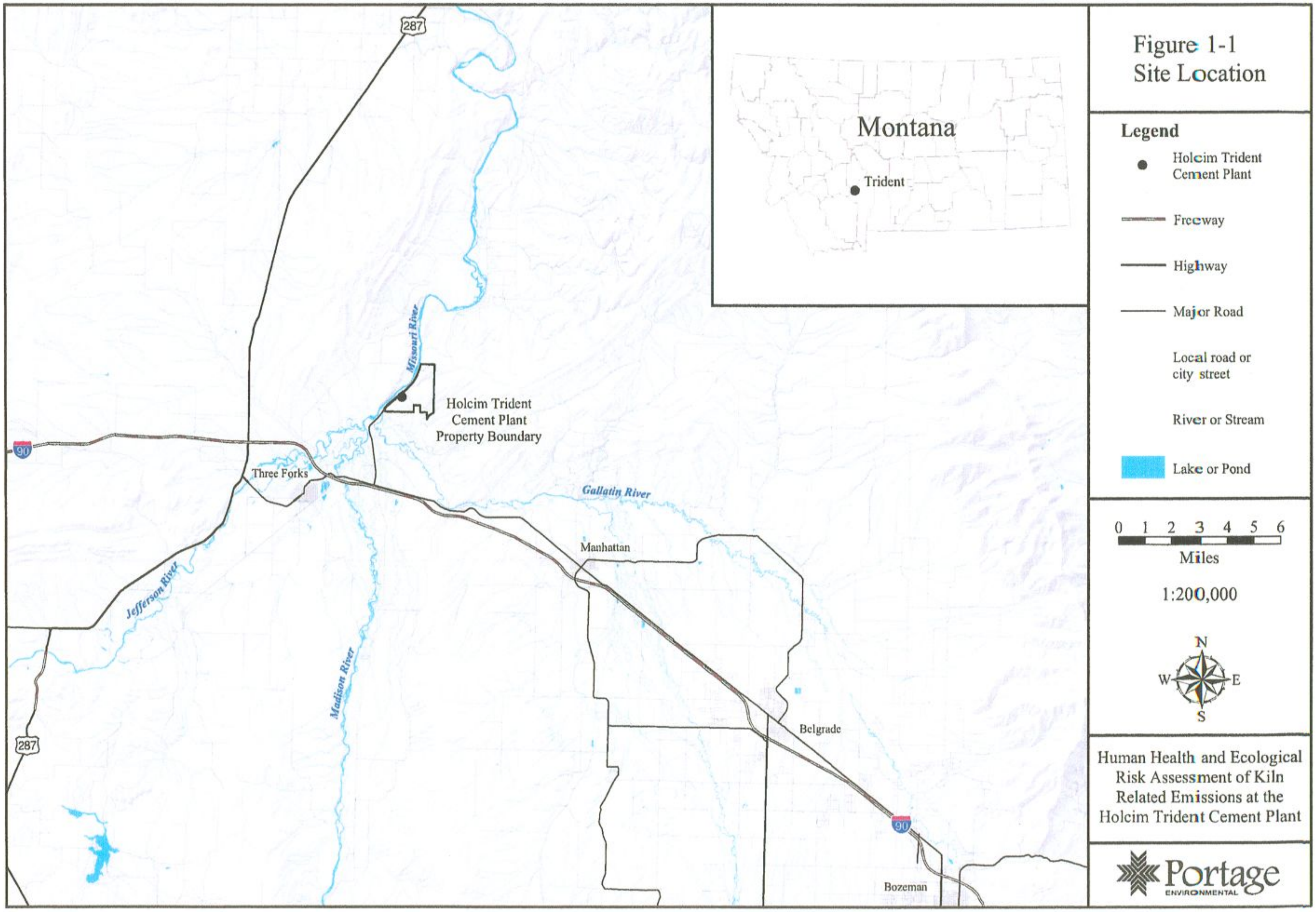
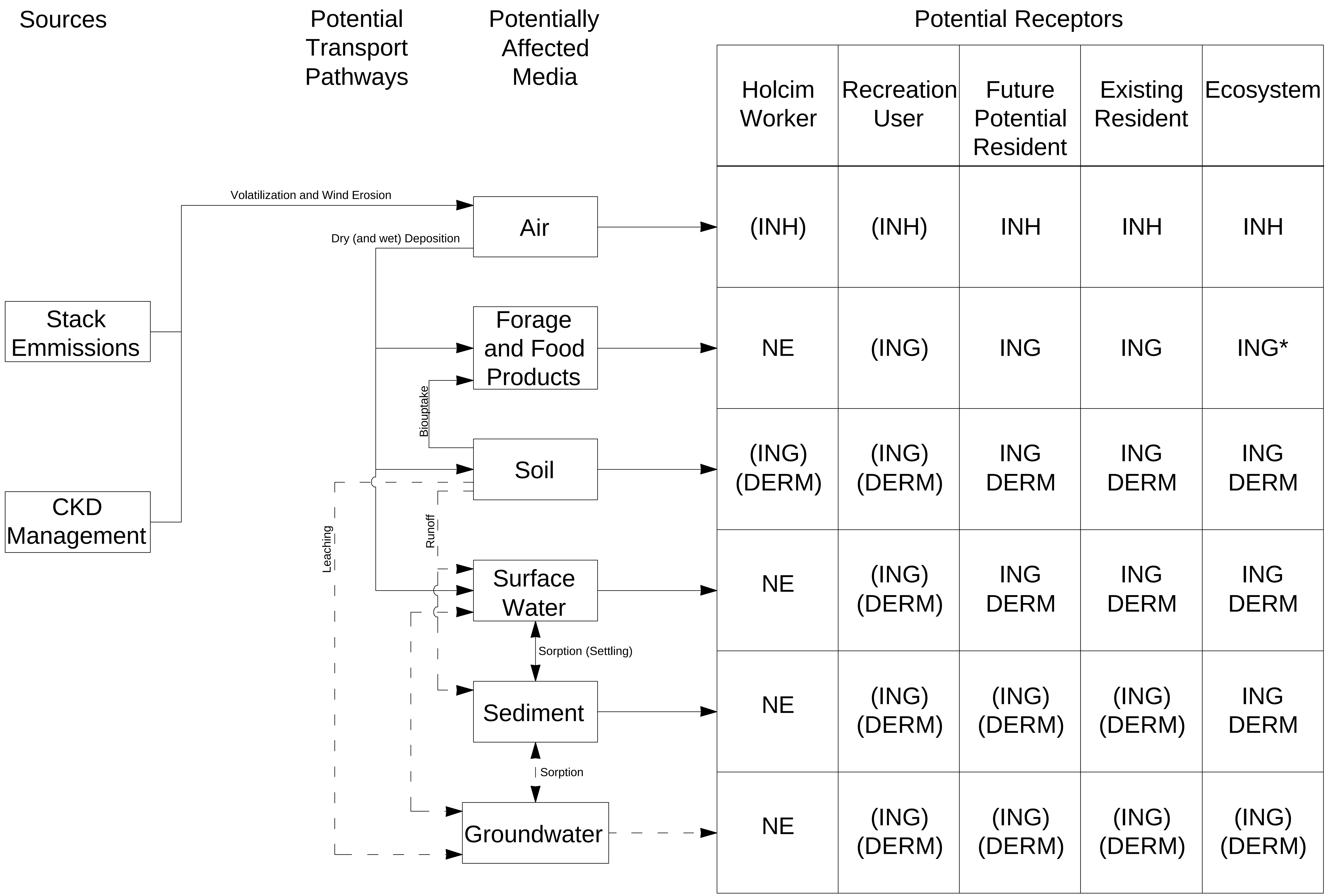


Figure 1-1
Site Location
Montana
Trident
Legend
Holcim Trident Cement Plant
Freeway
Highway
Major Road
Local road or city street
River or Stream
Lake or Pond
0 1 2 3 4 5 6
Miles
1:200,000
N
W
E
S
Human Health and Ecological Risk Assessment of Kiln Related Emissions at the Holcim Trident Cement Plant
Portage
ENVIRONMENTAL
287
Missouri River
Holcim Trident
Cement Plant
Property Boundary
90
Three Forks
Gallatin River
Manhattan
Jefferson River
Madison River
Belgrade
Bozeman



Media	Holcim Worker	Recreation User	Future Potential Resident	Existing Resident	Ecosystem
Air	(INH)	(INH)	INH	INH	INH
Forage and Food Products	NE	(ING)	ING	ING	ING*
Soil	(ING) (DERM)	(ING) (DERM)	ING DERM	ING DERM	ING DERM
Surface Water	NE	(ING) (DERM)	ING DERM	ING DERM	ING DERM
Sediment	NE	(ING) (DERM)	(ING) (DERM)	(ING) (DERM)	ING DERM
Groundwater	NE	(ING) (DERM)	(ING) (DERM)	(ING) (DERM)	(ING) (DERM)

LEGEND:

INH - Inhalation
ING - Ingestion
DERM - Dermal Absorption
NE - No Exposure

() - Potentially complete yet minor pathway that is evaluated qualitatively or semi-quantitatively
* - See food web model

Transport pathways evaluated quantitatively (solid line)
Transport pathways evaluated qualitatively (dashed line)

Figure 2-1. Conceptual Site Model

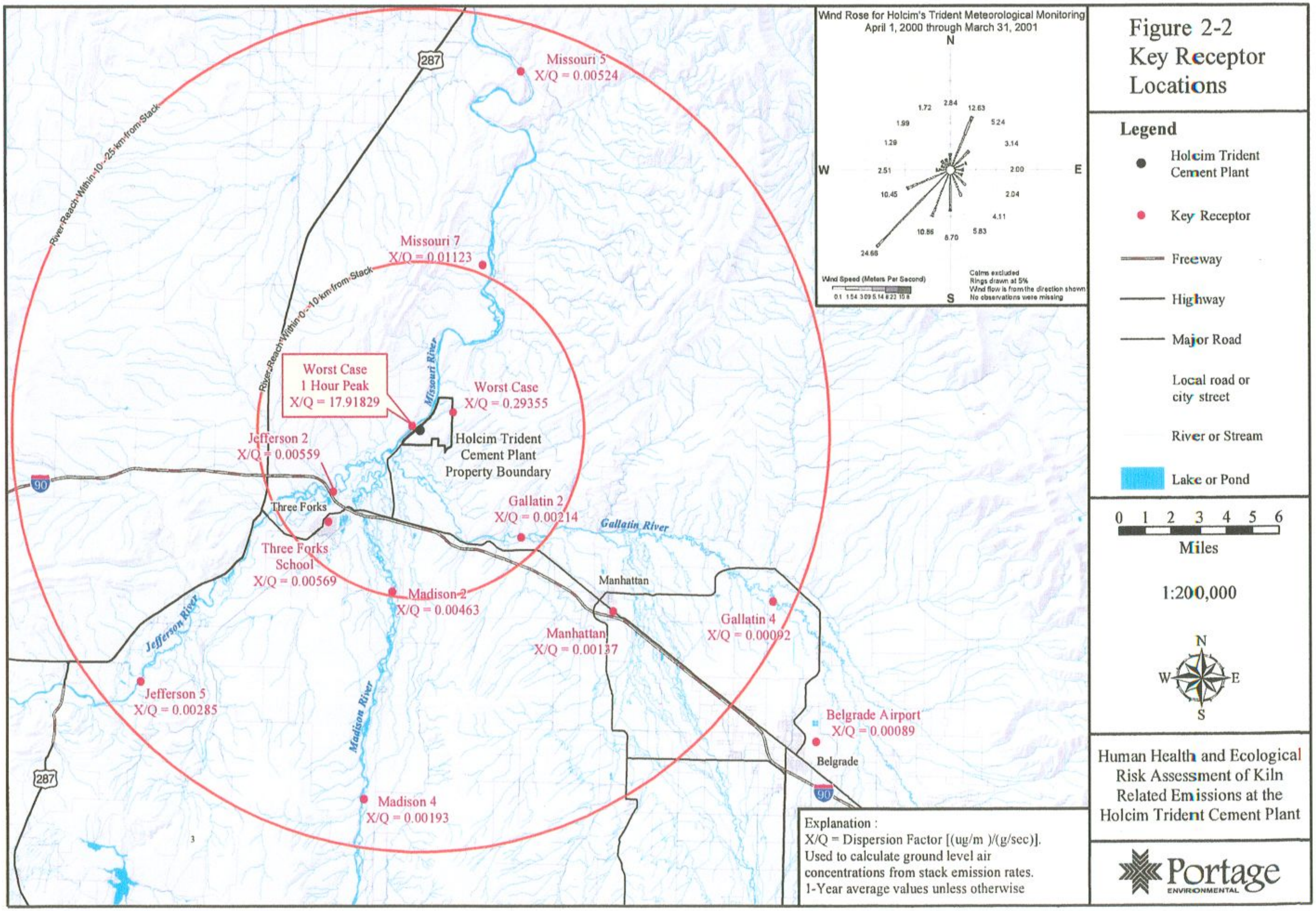
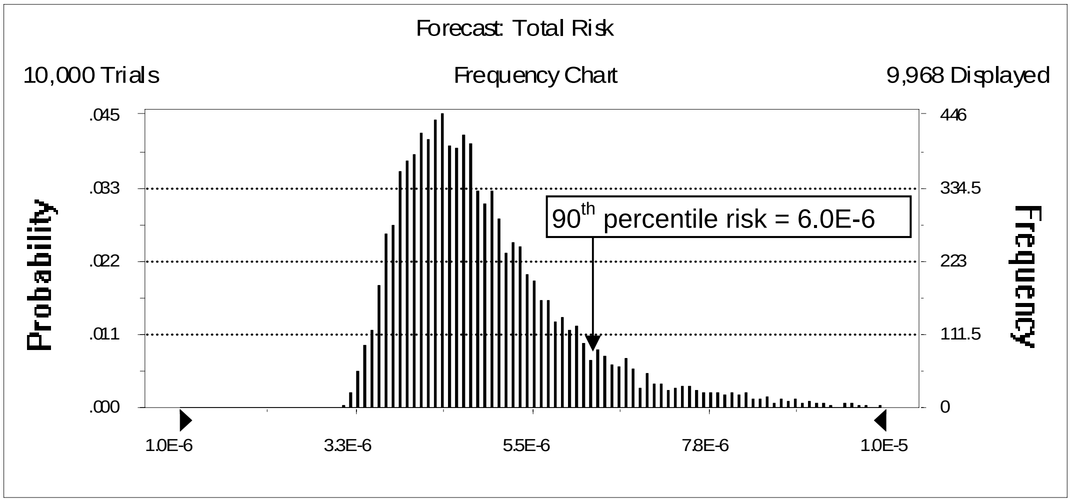


Figure 2-2
Key Receptor Locations
Legend
Holcim Trident Cement Plant
Key Receptor
Freeway
Highway
Major Road
Local road or city street
River or Stream
Lake or Pond
0 1 2 3 4 5 6
Miles
1:200,000
N
W
E
S
Human Health and Ecological Risk Assessment of Kiln Related Emissions at the Holcim Trident Cement Plant
Portage
ENVIRONMENTAL
Wind Rose for Holcim's Trident Meteorological Monitoring
April 1, 2000 through March 31, 2001
Calms excluded
Rings drawn at 5%
Wind flow is from the direction shown
No observations were missing
Wind Speed (Meters Per Second)
Missouri 5
X/Q = 0.00524
Missouri 7
X/Q = 0.01123
River Reach Within 10 - 25 km from Stack
River Reach Within 0 - 10 km from Stack
Worst Case
1 Hour Peak
X/Q = 17.91829
Worst Case
X/Q = 0.29355
Holcim Trident
Cement Plant
Property Boundary
Missouri River
Jefferson 2
X/Q = 0.00559
Three Forks
Three Forks
School
X/Q = 0.00569
Gallatin 2
X/Q = 0.00214
Gallatin River
Madison 2
X/Q = 0.00463
Manhattan
Manhattan
X/Q = 0.00137
Gallatin 4
X/Q = 0.00092
Jefferson River
Jefferson 5
X/Q = 0.00285
Madison River
Belgrade Airport
X/Q = 0.00089
Belgrade
Madison 4
X/Q = 0.00193
287
90
Explanation :
X/Q = Dispersion Factor [(ug/m)/(g/sec)].
Used to calculate ground level air concentrations from stack emission rates.
1-Year average values unless otherwise



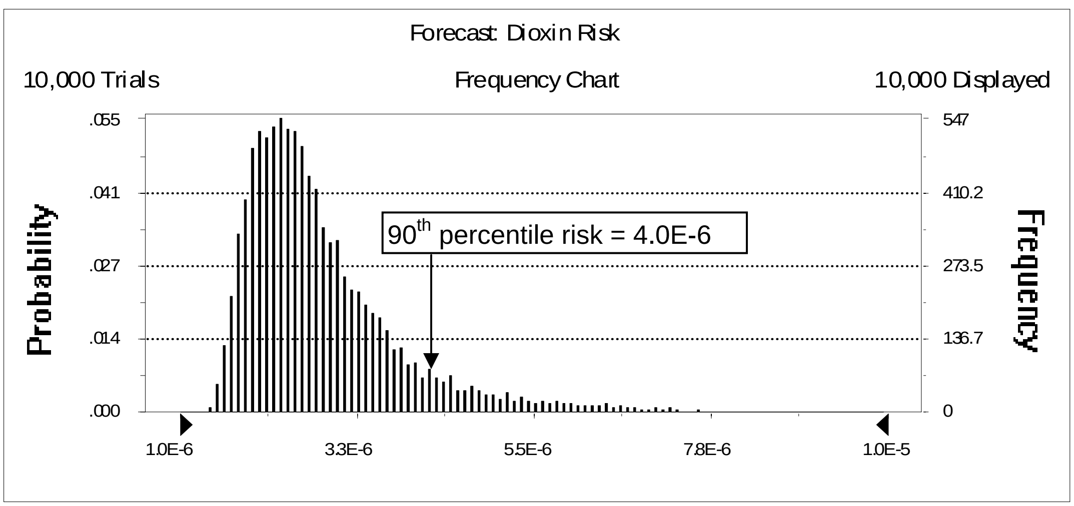


Figure 2-3. Population Distribution of Carcinogenic Risks for Worst Case Location Cumulative Condition

Figure 3-1. Holcim Terrestrial Food Web.

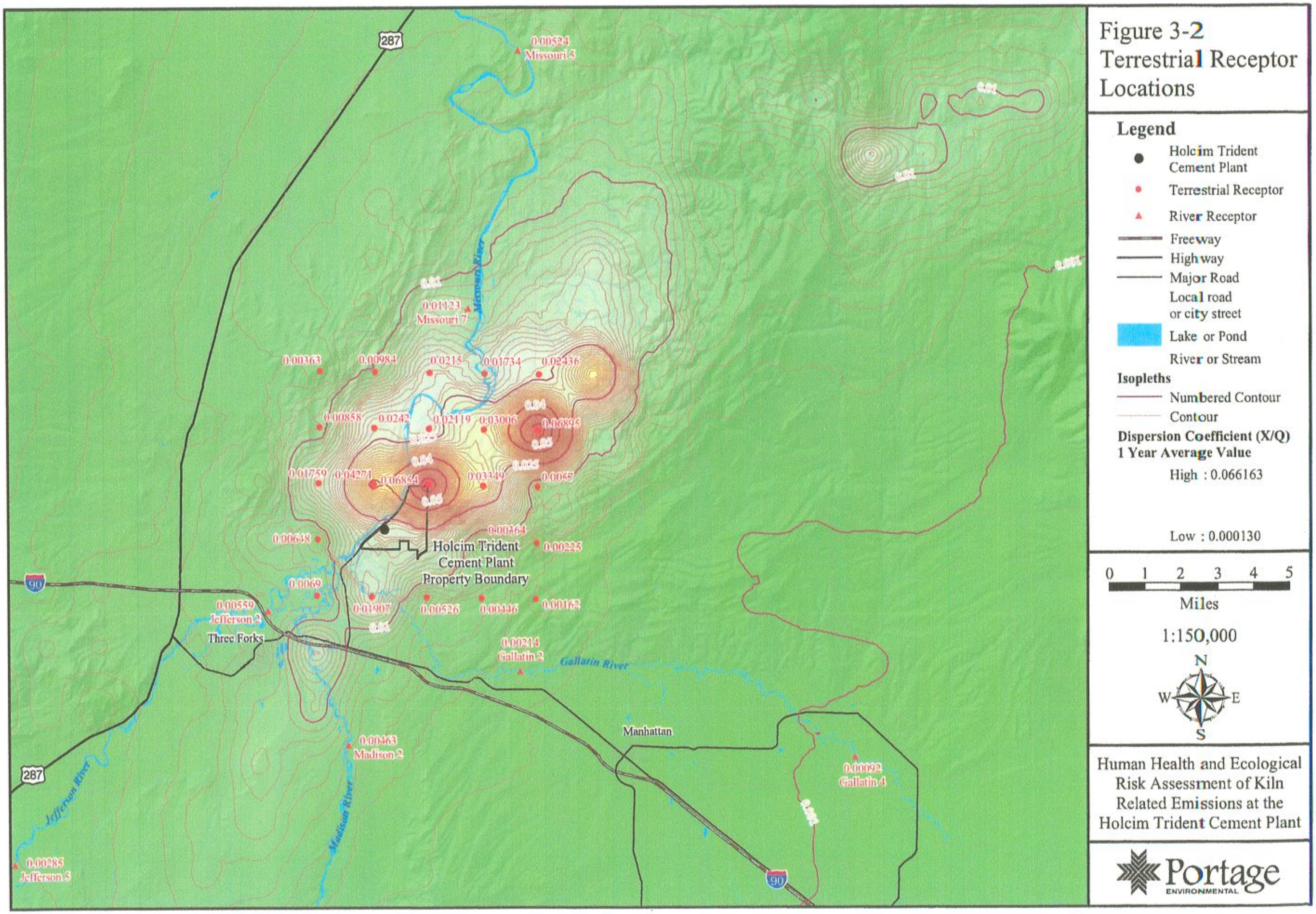


Figure 3-2
Terrestrial Receptor Locations

Table 2-1. Acute Hazards Assessment

Compound	Peak 1-hour (ug/m^3)[1] Baseline	Peak 1-hour (ug/m^3)[1] Cumulative	Upset Mult. Kiln (1-hr)[2]	Acute Criteria (ug/m^3)	Avg Time (hrs)	Source[3]	Hazard Quotent Baseline	Hazard Quotent Cumulative
Acetaldehyde	1.08E+00	1.53E-01	1	3.60E+05	8	OSHA	0.0000	0.0000
Acrolein	2.53E-02	2.53E-02	1	1.90E-01	1	CEPA	0.1333	0.1333
Trichloroethene	8.39E-04	7.11E-03	1	6.79E+05	1	ERPG-1	0.0000	0.0000
Antimony	7.61E-02	7.71E-02	83.8	1.49E+03	--	TEEL-1	0.0001	0.0001
Arsenic	1.31E-01	9.42E-02	83.8	3.00E+01	--	TEEL-1	0.0044	0.0031
Benzene	2.38E+00	1.95E+00	1	1.60E+05	1	ERPG-1	0.0000	0.0000
Beryllium	3.22E-02	2.42E-02	83.8	9.95E+00	--	TEEL-1	0.0032	0.0024
Bis (2-ethylhexyl)phthalate	1.11E-01	1.37E-01	1	5.00E+03	8	OSHA	0.0000	0.0000
Bromomethane (Methyl Bromide)	1.11E-02	7.39E-03	1	3.90E+03	1	CEPA	0.0000	0.0000
1,3 Butadiene/Butadiene	8.00E-03	2.06E-02	1	NA	NA	NA	--	--
2-Butanone (MEK)	2.30E-03	2.14E-03	1	1.30E+04	1	CEPA	0.0000	0.0000
Butylbenzylphthalate*	1.37E-04	1.37E-04	1	NA	NA	NA	--	--
Cadmium	1.97E-01	7.61E-02	83.8	2.99E+01	--	TEEL-1	0.0066	0.0025
Carbon Disulfide	2.94E-01	4.14E-02	1	3.11E+03	1	ERPG-1	0.0001	0.0000
Carbon Tetrachloride	8.63E-04	8.63E-04	1	1.26E+03	1	ERPG-1	0.0000	0.0000
Chlorine	1.36E+00	1.64E+00	1	2.10E+02	1	CEPA	0.0065	0.0078
Chlorobenzene	1.75E-02	1.77E-02	1	3.45E+05	--	TEEL-1	0.0000	0.0000
Chloromethane (Methyl chloride)	1.12E-01	4.65E-02	1	2.07E+05	--	TEEL-1	0.0000	0.0000
Chromium (total)*	3.00E-01	2.31E-01	83.8	1.49E+02	--	TEEL-1	0.0020	0.0015
Chromium 6	5.23E-02	2.80E-02	83.8	1.50E+02	--	TEEL-1	0.0003	0.0002
Cobalt	1.98E-01	1.23E-01	83.8	1.00E+02	8	OSHA	0.0020	0.0012
Di-n-Butyphthalate*	3.46E-03	3.46E-03	1	1.50E+04	--	TEEL-1	0.0000	0.0000
1,4 Dichlorobenzene	3.45E-03	2.28E-02	1	6.61E+05	--	TEEL-1	0.0000	0.0000
Dichloromethane	1.01E-01	7.00E-01	1	NA	NA	NA	--	--
Dimethyl Phthalate	4.80E-03	4.80E-03	1	5.00E+03	8	OSHA	0.0000	0.0000
2,4-Dinitrophenol	2.60E-02	3.84E-03	1	9.79E+02	--	TEEL-1	0.0000	0.0000
Ethylbenzene	5.01E-01	7.71E-01	1	5.43E+05	--	TEEL-1	0.0000	0.0000
Chloroethane (ethyl chloride)	7.36E-03	7.36E-03	1	2.60E+06	8	OSHA	0.0000	0.0000
Formaldehyde	2.80E+00	3.52E+00	1	9.40E+01	1	CEPA	0.0297	0.0374
Hydrogen chloride	8.45E+00	8.89E+00	5.14	2.10E+03	1	CEPA	0.0040	0.0042
Hydrogen fluoride	2.60E-01	4.02E-01	5.14	2.40E+02	1	CEPA	0.0011	0.0017
Lead	2.76E+00	2.80E+00	83.8	3.81E+01	--	TEEL-1	0.0724	0.0736
Manganese	3.38E+00	9.36E+00	83.8	5.00E+03	8	OSHA	0.0007	0.0019
Mercury	1.34E-01	1.81E-01	5.14	7.38E+01	--	TEEL-1	0.0018	0.0025
4-Methyl phenol	1.46E-02	1.14E-02	1	NA	NA	NA	--	--
Methylene chloride	9.43E-02	4.56E-01	1	1.40E+04	1	CEPA	0.0000	0.0000
Naphthalene	1.48E-01	1.19E-01	1	7.86E+04	--	TEEL-1	0.0000	0.0000
Nickel	3.43E-01	4.32E-01	83.8	6.00E+00	1	CEPA	0.0571	0.0721
Nitrobenzene	3.49E-03	3.74E-03	1	1.51E+04	--	TEEL-1	0.0000	0.0000
4-Nitrophenol	7.40E-02	7.40E-02	1	NA	NA	NA	--	--
Phenol	2.40E-01	1.53E-01	1	3.85E+04	1	ERPG-1	0.0000	0.0000
Phosphorus	6.97E-01	8.68E-01	1	1.00E+02	8	OSHA	0.0070	0.0087
Selenium	1.64E+00	1.02E+00	83.8	5.81E+02	--	TEEL-1	0.0028	0.0018
Styrene	6.12E-01	1.22E+00	1	2.10E+04	1	CEPA	0.0000	0.0001
1,1,1 Trichloroethane	4.16E-04	3.29E-03	1	NA	NA	NA	--	--
Toluene	2.98E+00	4.51E+00	1	3.70E+04	1	CEPA	0.0001	0.0001
Vinyl chloride	2.42E-02	4.31E-02	1	1.80E+05	1	CEPA	0.0000	0.0000
Xylenes, total	2.21E+00	3.59E+00	1	2.20E+04	1	CEPA	0.0001	0.0002
Zinc	1.07E+02	4.45E+01	83.8	1.00E+03	8	OSHA	0.1068	0.0445
TCDD Eq.	2.43E-06	2.43E-06	17.7	NA	NA	NA	--	--
Total PCBs	1.00E-03	9.42E-04	1	NA	NA	NA	--	--
PAH- Total	1.95E-01	1.45E-01	1	1.00E+03	--	TEEL-1	0.0002	0.0001
PAH-Non-carcinogenic totals	1.95E-01	1.44E-01	1	NA	NA	NA	--	--
PAH-Carcinogenic totals	1.14E-04	3.22E-04	1	NA	NA	NA	--	--
TOTAL HAZARD INDEX							0.44	0.40

[1]Highest 1-hour modeled concentration for worst case receptor, includes consideration of upset conditions.

[2]Upset Multiplier - factor used to account for a possible ESP shutdown when estimating peak 1-hour concentrations.

[3]In order of preference selected: CEPA - Air Toxics Hot Spots Program Risk Assessment Guidelines, Part 1, The Determination of Acute Referen Exposure Levels for Airborne Toxicants, California EPA, 1999, 1-hour values. AEGL-1 Level 1 Acute Exposure Guidelines for 1-hour exposure d National Advisory Committe, 1997. ERPG-1 Level 1 Emergency Response Planning Guidelines Levels, Subcommittee on Consequence Assessn Protective Guidelines, 1997. ATEL-1 Level 1 Acute Toxicity Exposure Levels, California EPA 1996 were not used due to the more recent CEPA v Protocol for Hazardous Waste Combustion Facilities Table A-4, July 1998, TEEL-1 Level 1 Temporary Emergency Exposure Limits, Subcommitte on Consequence Assessment and Protective Guidelines, 1997. OSHA - Time Weight Average Permissible Exposure Level, 29CFR1910.1000.

NA - Not Available

* Butylbenzylphthalate emissions are only from glass. Di-n-butylphthalate emissions include glass, total chromium emissions include glass.

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Table 3-1. Soil Toxicity Criteria (mg/kg)

	Regional Average Soil Concentration[1]		Highest Receptor Soil Concentration[1]		Detection	Geometric Mean U.S.	Human Health	Toxicity Reference Values[5]				Preliminary Remediation Goals[6]			Ecological Screening Values[7]
Deposition COPC	Baseline	Cumulative	Baseline	Cumulative	Limit[2]	Background[3]	PRG[4]	Plants	type	Invertebrates	type	General	Basis	Plants	EPA Region 4
Antimony	4.44E-04	4.50E-04	1.01E-01	1.02E-01	NR	NR	31	0.5	not specified	NR		5	plant	5	3.5
Arsenic	7.63E-04	5.50E-04	1.73E-01	1.25E-01	5.0	NR	0.39	1	corn	0.25	earthworm	9.9	shrew, plant	10	10
Beryllium	1.76E-04	1.32E-04	3.97E-02	2.98E-02	5.0	1	150	0.1	not specified	NR		10	plant	10	1.1
Cadmium	1.07E-03	4.15E-04	2.42E-01	9.39E-02	1.0	NR	37	0.2	spruce	10	earthworm	4	plant, woodcock	4	1.6
Chromium (+6)	2.85E-04	1.53E-04	6.46E-02	3.45E-02	NR	NR	30	0.018	lettuce	0.2	earthworm	NR		NR	NR
Chromium (+3)	1.75E-03	1.35E-03	3.97E-01	3.05E-01	5.0	37	10000	NR		NR		0.4	earthworm	1	0.4
Cobalt	1.15E-03	7.18E-04	2.61E-01	1.63E-01	5.0	7	900	NR		NR		20	plant	20	20
Lead	1.61E-02	1.64E-02	3.65E+00	3.71E+00	5.0	16	400	4.6	senna	100	earthworm	40.5	woodcock	50	50
Manganese	1.97E-02	5.47E-02	4.46E+00	**1.24E+01**	**5.0**	340	1800	NR		NR		NR		500	100
Mercury*	7.08E-04	9.57E-04	**1.60E-01**	**2.17E-01**	1.0	NR	23	0.349	barley	NR		**0.00051****	woodcock	0.3	**0.1**
Methylmercury*	1.45E-05	1.95E-05	3.27E-03	4.42E-03	NR	NR	NR	NR		2.5	earthworm	NR		NR	0.67
Nickel	2.00E-03	2.53E-03	4.53E-01	5.72E-01	5.0	14	1600	24	bush bean	100	earthworm	30	plant	30	30
Phosphorus	3.45E-03	4.41E-03	7.81E-01	9.98E-01	NR	NR	1.6	NR		NR		NR		NR	NR
Selenium	9.55E-03	5.95E-03	**2.16E+00**	**1.35E+00**	5.0	NR	390	**0.05**	alfalfa	7.7	earthworm	**0.21**	mouse	**1**	**0.81**
Zinc	6.24E-01	2.54E-01	**1.41E+02**	**5.75E+01**	**5.0**	**44**	2300	**0.9**	barley	199	earthworm	**8.5**	woodcock	**50**	**50**
Acrolein	1.34E-05	1.34E-05	3.04E-03	3.04E-03	NR	NR	0.1	NR		NR		NR		NR	NR
Dinitrophenol, 2,4-	1.32E-04	1.94E-05	2.98E-02	4.39E-03	1.65	NR	120	NR		NR		20	plant	20	20
4-Nitrophenol	1.75E-06	1.75E-06	3.97E-04	3.97E-04	0.33	NR	NR	NR		NR		7	earthworm	NR	7
Nitrobenzene	1.21E-05	1.29E-05	2.73E-03	2.93E-03	0.33	NR	20	NR		NR		NR		NR	40
Phenol	4.67E-05	2.97E-05	1.06E-02	6.73E-03	0.33	NR	3700	NR		NR		30	earthworm	70	0.05
Napthalene	7.18E-04	5.79E-04	**1.63E-01**	**1.31E-01**	0.33	NR	56	NR		NR		NR		NR	**0.1**
Acenapthene	--	--	--	--	0.33	NR	56	NR		NR		20	plant	20	20
Total PAH	0.001	0.001	0.333	0.247	0.33	NR	56/0.062***	1.2	wheat	25	woodlouse	NR		NR	1
Dioxin	9.3E-09	9.3E-09	2.1E-06	2.1E-06	1.0E-07	NR	3.96E-06	NR		0.5	earthworm	3.15E-06	shrew	NR	NR
PCBs	1.23E-05	1.15E-05	2.78E-03	2.61E-03	0.33	NR	0.22	10	soybean	2.5	earthworm	0.371	shrew	40	0.02

[1]Average predicted soil concentrations over a 100 year period of facility operations. Regional refers to the broader area surrounding the Facility. Highest Receptor refers to the point of maximum observed ground level air concentration.

[2]Detection Limit - From Engergy Laboratories, Inc, Analytical Services, 1999

[3]U.S. Background - Elemental Compostion of Surficial Materials in the Conterminous United States, USGS, 1971

[4]PRG - Preliminary Remediation Goals, EPA Region 9, Residential (http://www.epa.gov/region09/waste/sfund/prg/files/02table.pdf)

[5]TRV - Screening Level Ecological Risk Assessment Protocol, Appendix E, Table E-5 (Terrestrial Plants) and Table E-6 (Soil Invertebrates), EPA, 1999

[6]Preliminary Remediation Goals for Ecological Endpoints. General values from Efroymson (August 1997) which considers lowest value for wildlife, plants and soil invertebrates. Plant values from Efroymson (Nov. 1997) which considers phytotoxicity.

[7]Region 4 values from http://www.epa.gov/reg5rcra/ca/ESL.pdf with no basis listed, Region 5 values from http://www.epa.gov/reg5rcra/ca/ESL.pdf

*Dry land soils assumed to be 98% Hg^{2+} and 2% MHg, per Table B-1-1, Screening Level Ecological Risk Assessment Protocol, EPA, 1999

**Background value recommended for mercury in place of risk-based value

***Non-carcinogenic and carcinogenic values respectively. The total for carcinogenic constituents does not exceed the carcinogenic value (see Appendix A and B).

NR - Not Reported

Bolded chemical names indicate excedance of one or more comparison values

Table 3-2. Surface Water Toxicity Criteria (ug/L)

Deposition COPC	River Water Concentration[1]		Lake Water Concentration[1]		Montana Aquatic Life Standard[2]			Toxicity Reference Values[3]	Preliminary Remediation Goal[4]		EPA Region IV Surface Water Screening Values[5]
	Baseline	Cumulative	Baseline	Cumulative	Chronic	Trigger	Reporting Value		Value	Basis	
Antimony	0.000001	0.000001	0.000243	0.000246	NR	NR	3	30	30	aquatic	160
Arsenic	0.000001	0.000001	0.000416	0.000300	150	NA	3	150	190	piscivore	190
Beryllium	1.95E-07	1.47E-07	0.000079	0.000060	NR	NR	1	0.66	0.66	aquatic	530
Cadmium	0.000001	4.62E-07	0.000483	0.000187	0.27	0.1	0.1	2.2	1.1	aquatic	0.66
Chromium (+6)	3.18E-07	1.69E-07	0.000129	0.000069	86.2	NR	5	11	11	aquatic	11
Chromium (+3)	0.000002	0.000002	0.000957	0.000735	NR	1	1	NR	210	aquatic	117
Cobalt	0.000001	0.000001	0.000630	0.000392	NR	NR	NR	NR	23	aquatic	NR
Lead	0.000019	0.000019	0.008797	0.008942	3.18	0.1	3	2.5	3.2	aquatic	1.32
Manganese	0.000023	0.000065	0.010766	0.029860	NR	NA	5	NR	120	aquatic	NR
Mercury[6]	0.000001	0.000006	0.000236	0.002121	0.91	NA	0.6	0.77	1.3	aquatic	0.012*
Methylmercury[6]	1.15E-07	0.000001	0.000042	0.000374	NR	NR	NR	0.0028	0.0026	piscivore	NR
Nickel	0.000002	0.000003	0.001093	0.001379	52.2	0.5	20	52	160	aquatic	87.71
Phosphorus	0.000005	0.000006	0.002221	0.002770	nutrient	1	1	NR	NR		NR
Selenium	0.000011	0.000007	0.005216	0.003249	5	0.6	1	5	0.39	piscivore	5
Zinc	0.000740	0.000288	0.340558	0.125755	119.8	5	10	118	110	aquatic	58
Acrolein	0.000005	0.000005	0.001659	0.001659	NR	0.7	20	NR	NR		2.1
Dinitrophenol, 2,4-	0.000005	0.000001	0.001707	0.000251	NR	13	50	NR	NR		6.2
4-Nitrophenol	0.000013	0.000013	0.004850	0.004849	NR	2.4	NR	NR	300	aquatic	82.8
Nitrobenzene	0.000001	0.000001	0.000229	0.000245	NR	0.45	NR	66.8	NR		270
Phenol	0.000043	0.000028	0.015705	0.009990	NR	100	10	NR	110	aquatic	256
Napthalene	0.000027	0.000022	0.009658	0.007783	NR	0.04	10	NR	12	aquatic	62
Total PAH	0.000009	0.000005	0.003107	0.001689	NR	NR	NR	0.014	NR		NR
Dioxin	3.25E-11	3.25E-11	1.26E-08	1.26E-08	NR	NA	1	3.80E-06	NR		NR
PCBs	1.81E-07	1.71E-07	0.000066	0.000062	0.014	NA	1	0.19	0.0019	piscovore	0.014

[1]Average predicted surface water concentrations in the during facility operations

[2]From Circular WQB-7, Chronic Aquatic Life and Trigger Value. Trigger Values are used to determine if a given increase in the concentration of toxic parameters is significant or non-significant as per the non-degradation rules.

Hardness of 100 for hardness dependent criteria (Cd, Cr, Pb, Ni, Zn)

[3]TRV - Screening Level Ecological Risk Assessment Protocol, Appendix E, Table E-1 (Freshwater), EPA, 1999

[4]Lowest of Ambient Water Quality Criteria or piscivorous wildlife health based values, Efroymson (August, 1997)

[5]Derived from Ambient Water Quality Criteria or lowest reported effect level.

[6]85% inorganic mercury and 15% methylmercury per Table B-1-1 of Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, EPA, 1999.

*Based on the marketability of fish, other health-based values may be used.

Nutrient - A plant nutrient, excessive amounts of which may cause violations of ARM 17.30.637 (1)(e).

NR - Not Reported

NA - Not Applicable

Table 3-3. Sediment Toxicity Criteria (mg/kg dry weight)

Deposition COPC	River Sediment Concentration[1]		Lake Sediment Concentration[1]		TRV[2]	PRG[3]	ESV[4]	
	Baseline	Cumulative	Baseline	Cumulative			Region 4	Region 5
Antimony	2.83E-11	2.87E-11	1.30E-08	1.32E-08	64	NR	12	NR
Arsenic	4.33E-11	3.12E-11	1.99E-08	1.44E-08	6	42	7.24	9.79
Beryllium	5.26E-13	3.95E-13	2.14E-10	1.60E-10	NR	NR	NR	NR
Cadmium	1.01E-11	3.93E-12	4.11E-09	1.59E-09	0.6	4.2	NR	0.99
Chromium (+6)	--	--	--	--	26	NR	NR	NR
Chromium (+3)	--	--	--	--	NR	159	52.3	43.4
Cobalt	2.32E-11	1.45E-11	1.07E-08	6.66E-09	NR	NR	NR	50
Lead	--	--	--	--	31	110	30.2	35.8
Manganese	--	--	--	--	NR	NR	NR	NR
Mercury*	1.04E-09	1.04E-09	4.72E-07	4.80E-07	0.2	0.7	0.13	0.174
Methylmercury*	3.97E-10	1.10E-09	1.83E-07	5.07E-07	0.2	NR	NR	NR
Nickel	2.71E-11	2.44E-10	9.82E-09	8.84E-08	16	38.5	15.9	22.7
Phosphorus	1.38E-12	1.24E-11	5.00E-10	4.50E-09	NR	NR	NR	NR
Selenium	6.39E-12	8.06E-12	2.94E-09	3.71E-09	0.1	NR	NR	NR
Zinc	--	--	--	--	110	270	124	121
Acrolein	4.70E-11	4.70E-11	1.70E-08	1.70E-08	NR	NR	NR	1.52E-06
Dinitrophenol, 2,4-	2.06E-09	3.03E-10	7.45E-07	1.10E-07	NR	NR	NR	0.0062
4-Nitrophenol	1.02E-08	1.02E-08	3.68E-06	3.68E-06	NR	NR	NR	NR
Nitrobenzene	4.18E-10	4.48E-10	1.51E-07	1.62E-07	1.3	NR	NR	0.0086
Phenol	1.19E-08	7.61E-09	4.33E-06	2.75E-06	NR	0.032	NR	0.0491
Napthalene	4.64E-07	3.74E-07	1.68E-04	1.35E-04	NR	0.39	0.33	0.176
Total PAH	9.16E-05	4.94E-05	3.31E-02	1.79E-02	0.17	13.66	1.684	NR
Dioxin	2.05E-09	2.05E-09	7.95E-07	7.95E-07	0.00041	NR	2.50E-06	NR
PCBs	4.92E-10	4.92E-10	1.91E-07	9.34E-04	0.05	0.18	0.033	0.0598

[1]Average predicted sediment concentrations based on river water concentrations

[2]Toxicty Reference Value - Screening Level Ecological Risk Assessment Protocol, Appendix E, Table E-3 (Freshwater Sediments), EPA, 1999

[3]Preliminary Remediation Goals for Ecological Endpoints, Efroymson (August, 1997)

[4]Ecological Screening Values - Region 4 values from http://www.epa.gov/reg5rcra/ca/ESL.pdf with no basis listed, Region 5 values from http://www.epa.gov/reg5rcra/ca/ESL.pdf

*Wetland soils assumed to be 85% Hg^{2+} and 15% MHg, per Table B-1-1, Screening Level Ecological Risk Assessment Protocol, EPA, 1999

NR - Not Reported

-- No Koc value to support calculating sediment concentration

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT OF KILN-RELATED EMISSIONS AT THE HOLCIM TRIDENT CEMENT PLANT

- DRAFT -

VOLUME 1 OF 2

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GLOSSARY OF RISK ASSESSMENT TERMINOLOGY

TERM	DEFINITION
Cancer Slope Factor	A plausible upper-bound estimate of the probability of a response per unit intake of a constituent over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer over a lifetime as a result of exposure to a particular level of a potential carcinogen.
Chronic Reference Dose (RfD)	An estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a maximum daily exposure level for the human population, including sensitive sub-populations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Chronic RfDs are specifically developed to be protective for long-term exposure to a compound (as a Superfund program guideline, seven years to lifetime).
Constituents of Potential Concern	Chemicals that are potentially site-related and whose data are of sufficient quality for use in the quantitative risk assessment.
Dose	A quantity of constituent exposure occurring at one time.
Excess Lifetime Cancer Risk	Upper-bound estimate of the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen; calculated as the product of the cancer slope factor and exposure dose.
Exposure	Contact of an organism with a constituent or physical agent. Exposure is quantified as the amount of the agent available at the exchange boundaries of the organism and available for absorption.
Exposure Pathway	The course a constituent or physical agent takes from a source to an exposed organism. An exposure pathway describes a unique mechanism by which an individual or population is exposed to constituents or physical agents at or originating from a site. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs for the source, a transport/exposure medium (e.g., air) or media (in cases of inter-media transfer) must also be included.

GLOSSARY OF RISK ASSESSMENT TERMINOLOGY (CONTINUED)

TERM	DEFINITION
Exposure Point	A location of potential contact between an organism and a constituent or physical agent.
Exposure Route	The way a constituent or physical agent comes in contact with an organism (i.e., by ingestion, inhalation, dermal contact).
Hazard Index (HI)	The sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. Separate HIs are calculated to assess non-carcinogenic effects from chronic, subchronic, and shorter duration exposures.
Hazard Quotient (HQ)	The ratio of a single substance exposure level over a specified time period (e.g., chronic) to a reference dose for that substance derived from a similar exposure period.
Integrated Risk Information System (IRIS)	A U.S. Environmental Protection Agency (EPA) database containing verified reference doses and cancer slope factors and up-to-date health risk and EPA regulatory information for numerous constituents.
Qualitative Evaluation	A descriptive assessment of potential risks and hazards associated with exposure.
Quantitative Evaluation	A numerical estimate of potential risks and hazards associated with exposure.
Receptor	Individual or population potentially exposed to constituents at an exposure point. An integral component of the exposure pathway.
Toxicity Factor	A numerical expression of a constituent’s dose-response relationship that is used in risk assessments. The most common are RfDs and cancer slope factors.
Upper Confidence Level	The percent likelihood that the arithmetic mean concentration for a constituent lies below the target concentration. A high level of confidence (95 percent) is used to compensate for the uncertainty involved in representing site conditions with a finite number of samples.

ACRONYMS

AERMOD	AMS/EPA Regulatory Model
ARM	Administrative Rules of Montana
CAPCOA	California Air Pollution Control Officers Association
CKD	cement kiln dust
COPC	constituent of potential concern
DEQ	Montana Department of Environmental Quality
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESP	electrostatic precipitator
GIRAS	Geographic Information Retrieval and Analysis System
GIS	Geographic Information System
HAP	hazardous air pollutant
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic Model for Lead in Children
IRIS	Integrated Risk Information System
LOAEL	lowest observed adverse effect level
NESHAP	National Emission Standard for Hazardous Air Pollutants
NOAEL	no observed adverse effect level
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PC-MACT	Portland Cement Maximum Achievable Control Technology
RfD	reference dose
SLERA	screening level ecological risk assessment

EXECUTIVE SUMMARY

Objectives

This risk assessment concerns Holcim's Portland Cement Manufacturing Facility (hereinafter Facility) in Trident, Montana. The Facility is presently permitted to burn up to 100 percent natural gas, up to 100 percent coal, up to 100 percent coke, or any combination of these. Holcim is also permitted to burn up to 800 tons per year of post consumer recycled glass and to use slag as a raw material because of its iron content.

Holcim is proposing to augment up to 15 percent of the total heat input into the kiln by the mid-kiln addition of whole passenger and light truck tires (termed Whole Tires). The proposal is described in *An Application for Alteration to Montana Air Quality Permit #0982-11* (Bison and Kleinfelder 2004a).

Prior risk assessments were performed by Holcim as part of their application to comply with the Administrative Rules of Montana (ARM 17.8.770), which requires that the change in risk from exposure to hazardous air pollutants (HAPs) associated with the proposed action be below negligible risk levels. Negligible risk is defined in ARM 17.8.740 as an increase in the excess lifetime cancer risk of less than 1×10^{-6} for any individual carcinogen, an increase in the excess lifetime cancer risk of less than 1×10^{-5} for the aggregate of all carcinogens, and an increase in the sum of the non-cancer hazard quotient of less than 1.0. The prior risk assessments demonstrated compliance with ARM 17.8.770; however, an environmental impact statement (EIS) was deemed necessary to support any decision to modify Holcim's permit.

As a technical report supporting the EIS, this assessment evaluates risks to human health and the environment associated with currently permitted operations (the baseline condition) and with proposed operation alterations (the cumulative condition) at the Facility.

Emissions Estimates and Dispersion Modeling

The assessment first involves estimating ground-level air concentrations for the baseline and current condition. This work is the subject of a separate report (Lorenzen 2004), and it is summarized in this assessment. The determination of Ground-level air concentrations involves estimating emission rates and performing dispersion modeling. Stack emission rates are based on data available from thirteen other facilities. The data from these other facilities are statistically evaluated to determine stack emission rates for the Trident Facility. Corrections are made to the emission rates to account for Facility upsets (based on a 2-year record of upsets at the Facility) and wind dispersion of cement kiln dust. Emission rate were also increased to incorporate the use of slag and glass as feed materials in the Facility's kiln.

Dispersion modeling is used to estimate Ground-level air concentrations from emission estimates. Dispersion modeling is performed using AERMOD software, an EPA approved model. Ground-level air concentrations are estimated for the worst case 1-hour peak location, worst case annual average location, locations in or near Three Forks, Manhattan, and Belgrade, and at receptor points located on the Jefferson, Madison, Gallatin and Missouri Rivers. Locally, the wind generally blows from the southwest to the northeast, following the Missouri River. The annual average worst-case location is therefore located along the Holcim property boundary, northeast of the stack.

Human Health Risk Assessment Methodology

Ground-level air concentrations are used as inputs into risk assessment models that predict the transport of constituents of potential concern in the environment and the resulting exposure to people, plants and animals. The Air Toxics Hot Spots model developed by California EPA (2003) was selected for use over the Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities developed by EPA (1998) because of its relative simplicity and health protectiveness. The California EPA model also provides an agency approved methodology for conducting a stochastic evaluation of the distribution of risk across the population, a feature not provided in EPA’s model. The California EPA model is used to predict constituent concentrations in soil, surface water, and a variety of domestic and wild food products. The model also estimates potential exposure of people to the constituents in each of these media. The most important distinction between the two models as applies to this risk assessment is the inclusion of the dioxin exposure via the mother’s milk pathway in the California EPA model. This pathway is not included in the EPA model, and it produces the highest predicted contributor to carcinogenic risk.

Very few changes are made to the default assumptions in the California EPA risk assessment model. The concentrations of constituents in soil are based on a 100-year period of operation in accordance with EPA (1999a) guidance, rather the default value of 70 years recommended by the California EPA model. Constituents emitted from the Facility will accumulate in soil until rates of decay (i.e. half-life) equilibrate with deposition rates. Since metals have the longest half-life, metals are predicted to increase throughout the 100-year period. However, even after 100 years of operation, metals concentrations are expected to be below detection limits achievable using routine analytical methods and to be below screening level risk-based concentrations established by EPA Region 9. Zinc is an exception, with concentrations predicted to exceed detection limits within 10 years but to remain below risk-based screening levels for well over 100 years. Information from EPA is used in other cases where data is not provided by the California EPA model. For example, several parameters necessary to model the transport of mercury in the environment were obtained from EPA guidance.

The resulting exposures, in terms of an average daily dose, are compared to toxicity factors developed by EPA to determine risks. The potential for acute risk from short-term exposure is also evaluated. Lead exposure is evaluated as a special case, using the EPA Integrated Exposure and Uptake Biokinetic model.

Human Health Risk Assessment Results

Acute risk and risk from potential lead exposure at their respective worst case locations are predicted to be below levels of concern. Carcinogenic risks are evaluated for a variety of exposure scenarios because there is no “bright line” below which it is generally agreed there is no concern from exposure, and because even very low levels of exposure can result in unacceptable risk.

People working and living in different locations and with different lifestyles are expected to have different levels of exposure and risk. Lifestyle factors relevant to this assessment include water and food ingestion rates, source of food (grocery store, gardens, fish and game from the area around the Facility), and hygiene habits that influence incidental soil ingestion rates. The range of risks estimates are as follows:

Location and Lifestyle Related Variability in Risk for the Cumulative Condition

Exposure Scenario	Average Exposure	High-End Exposure
Worst-case Location	2×10^{-6}	1×10^{-5}
Three Forks, Manhattan, Belgrade*	2×10^{-9}	4×10^{-7}
River Fish (consumption only)	2×10^{-8}	2×10^{-8}
Pond Fish (consumption only)**	5×10^{-7}	6×10^{-6}
Big Game (consumption only)**	5×10^{-9}	3×10^{-7}

Note: a risk of 2×10^{-6} can also be expressed as 2 cancers in 1,000,000 people exposed for a lifetime.
*Average scenario is based on non-ingestion pathways and air concentrations at the Belgrade airport, while the high-end exposure is based on the most likely scenario risks for Three Forks residents who ingest some foods produced from the area around the Facility.
*Pond fish risks are highly dependent upon the location of the pond and pond characteristics that affect the potential for accumulation of COPCs. Big game risks are dependent upon the size of the area around the facility over which animal exposure is averaged.

Stochastic evaluations of risk for the worst case exposure location are provided using Monte Carlo methodology. The results of these evaluations show how risks are distributed across the population and reveal the degree of protectiveness associated with the high-end risk estimate. Monte Carlo calculates a range of outputs based on a range of inputs. The input ranges are described as distributions and are part of the California EPA model.

As expected, the Monte Carlo analysis indicates that risks are lognormally distributed. Most people have exposure and risk that approximates the average exposure, while a few people have risks estimated by the high-end exposure. For this assessment, the high-end exposure estimates are expected to be protective of 100 percent of the people, while risks at the 90th percentile of the distribution are nearly half as high as the high-end (i.e. 100 percentile) exposure.

A discussion is provided regarding the uncertainty and variability of both the exposure estimates and the toxicity factors used to calculate risk. By adhering to an agency-approved methodology while accounting for site-specific factors where possible, the results of this assessment may be compared with risks estimated using the same methodology at other sites. In this manner, this risk assessment is intended to provide a consistent and health protective basis for understanding risks and making decisions.

The results of this risk assessment indicate that a vast majority of the people in the area are predicted to experience risks that are at levels at or below the range that is generally considered to be acceptable (1×10^{-4} to 1×10^{-6}). These risks are the incrementally increased risk of getting cancer as a result of lifetime exposure to COPCs from the site. The background rate of cancer from all sources (natural and anthropogenic) is 1 in 3. Certain types of land use and lifestyles in close proximity to the Facility would result in larger incrementally increased cancer risk than would be experienced by the general population; for example subsistence living or concentrated agricultural operations such as feed lots, green houses, fish farms, or organic farms.

Ecological Risk Assessment Methodology

The ecological risk assessment uses the aforementioned human health risk assessment model to predict the transport of chemicals in the environment. Additional considerations in the ecological risk assessment include: the area over which exposure should be evaluated to provide ecologically meaningful results, the soil depth used to determine COPCs concentrations, and the need to select wildlife species that are representative of the area.

Exposure is evaluated at the point of worst-case annual average Ground-level air concentrations and over a 36-square mile area surrounding the facility. The selection of a 36-square mile area is subjective and considers: recognition that ecological risk is more concerned with ecosystem health than the health of individual organisms, the desire to select a large enough area that if affected would result in significant ecological impacts to the area, and the desire to include areas of highest potential ground-level air concentrations.

The soil depth was varied to reflect a range of values recommended by the California EPA and EPA. A soil depth of 0.15 meters and a soil bulk density of 1,333 kg/m^3 is used for calculating soil concentrations in the default models used in this ecological risk assessment; a value defined by California EPA guidance (2003) for agricultural exposure pathways in the human health risk assessment. Conversely, U.S. EPA guidance (1999a) suggests 0.01-meter soil depth be used for untilled soil and 0.2-meter depth be used for tilled soil. EPA also assumes a different soil bulk density of 1,500 kg/m^3. This assessment evaluated risks based on both a 0.01 meter depth and a 0.15 meter depth.

Environmental media concentrations predicted using the procedures described above are input into a site-specific food web model developed in accordance with EPA (1999a) guidance. Focusing on the terrestrial environment, species were selected to represent various types of species that may exist in the area, giving consideration to: species for which there is toxicity information, species of special economic value, rare species, species of interest to the public, and species in various trophic levels of the food web.

Bioconcentration is assessed quantitatively in the model, while bioaccumulation is assessed qualitatively. Toxicity factors were obtained from a variety of literature sources in accordance with EPA (1999a) guidance, relying in part on toxicity factors provided in Holcim's application. Risks to species in the aquatic environment are assessed using ambient water quality criteria.

In general terms, ecological hazards are characterized by dividing media concentrations or exposed dose by the appropriate standard or toxicity factor for each constituent. A hazard quotient (HQ) value greater than 1.0 is obtained if the media concentration or exposed dose exceeds the standard or toxicity factor, implying a potential hazard. The HQs are summed for all constituents to determine the hazard index (HI), thereby accounting for synergistic effects in a simplified manner. While the HI is provided based on the HQs for all COPCs as a simplified screening tool, it is only meaningful for evaluating risk from exposure to multiple COPCs that have similar toxic effects.

Ecological Risk Assessment Results

Potential hazards in the terrestrial environment may exist for small herbivorous and omnivorous birds such as robins and meadowlarks that have home territories of limited range in areas of highest ground-level air concentrations. The highest HI was 1.0, which occurred for the baseline condition at the worst case receptor when using California EPA soil depth and soil bulk density assumptions. An HI of 1.0 was also calculated for the baseline condition in the 36-square mile area surrounding the Facility when using EPA soil depth and soil bulk density assumptions. Metals are the primary contributors to the elevated HI, although no single metal has a hazard quotient greater than 1.0. A review of the toxic endpoints for each COPC that contributed substantially to the HI is not provided in this assessment.

Avian carnivores may also be at risk from exposure to dioxin in soil. The HIs may be above or below 1.0 depending on the assumptions used to determine soil mixing depth and soil bulk density. Dioxin emissions are set equal to their regulatory limit (0.2 lb/hr), while the average test data for the Facility indicates dioxin emission rates that are nearly 100 times lower (0.00207 lbs/hr) (Lorenzen 2004, Appendix C). If the actual emission rates were used in the model, the HI for avian carnivores would be much less than 1.0.

HIs for terrestrial species other than birds were below 1.0 for all scenarios evaluated. Potential hazards in river systems are also very low because of the large dilution associated with flowing water.

Potential hazards in lakes, ponds, and reservoirs will vary greatly depending upon the location of the water body, the size and depth of the water body, and the number of times per year the water volume in the water body changes. This assessment evaluated water concentrations in a pond that may be considered typical of water bodies in the Three Forks Area. The risk assessment focuses on risk to aquatic life, namely fish. Comparisons of predicted water quality to water quality standards are provided to support an assessment of aquatic ecosystems generally, including higher trophic level organisms. Predicted surface water concentrations for all constituents are below Montana Aquatic Life Standards

(Table 3-2). Therefore, hazards to aquatic life in most water bodies in the Three Forks Area are expected to be below levels of potential concern.

Potential hazards (HQs greater than 1) may occur for aquatic life and invertebrates in shallow ponds that have minimal water recharge and that may now, or in the future, be located in close proximity to the Facility. Potential aquatic life toxicity in lakes and ponds may reduce food abundance for higher trophic level organisms and thereby more broadly affect general ecosystem health. The river ecosystem may off-set any such reduced food abundance.

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT OF KILN-RELATED EMISSIONS AT THE HOLCIM TRIDENT CEMENT PLANT

1. SCOPING

1.1 OBJECTIVE

The objective of this assessment is to evaluate risks to human health and the environment associated with currently permitted operations and with proposed operation alterations at Holcim's Portland Cement Manufacturing Facility (hereinafter Facility) in Trident, Montana (Figure 1-1). The information provided by this risk assessment is intended to support an Environmental Impact Statement (EIS) prepared in accordance with the Montana Environmental Policy Act (75-1-101 et seq., 1971).

Holcim is already permitted to burn up to 100 percent natural gas, up to 100 percent coal, up to 100 percent coke, or any combination of these. Holcim is also permitted to burn up to 800 tons per year of post consumer recycled glass. Holcim also uses slag as a raw material because of its iron content. This permitted condition is referred to in this report as the baseline condition.

Holcim is proposing to augment up to 15 percent of the total heat input into the kiln by the mid-kiln addition of whole passenger and light truck tires (termed Whole Tires). The proposal is described in *An Application for Alteration to Montana Air Quality Permit #0982-11* (Bison and Kleinfelder 2004a). This proposed operation alteration is referred to in this report as the cumulative condition.

1.2 ORGANIZATION AND APPROACH

The remainder of Section 1 identifies the rationale supporting the general approach to completing the risk assessment. Section 2 presents the human health risk assessment and Section 3 presents the ecological risk assessment. The risk assessment calculations supporting the text are provided in appendices that comprise Volume II of the report.

This assessment is based on estimated ground-level air concentrations. These ground-level air concentrations are input into human health and ecological risk assessment models to determine exposure and risk. Calculations used to estimate ground-level air concentration based on Facility emissions are provided in Attachment A. The emissions inventory and dispersion modeling that are used to determine the ground-level air concentrations are described in detail in a separate report (Lorenzen 2004).

For both the human health and ecological risk assessment, risks are evaluated for both a baseline condition (no Whole Tires) and a cumulative condition (including Whole Tires). A "default" assessment has been completed that explicitly shows all equations, model input assumptions, and calculations. Printouts of the "default" assessment are provided in

Volume II, Attachments B through F. The attachments present all the equations used in the risk assessment, and are intended to allow a reviewer to reproduce the calculations. Accordingly, the body of this report does not describe the model and calculations in detail. Rather, the body of this report places emphasis in two areas: presenting a conceptual site model that supports a quantitative assessment of exposure, and presenting the results and conclusions of the risk assessment. Considerable emphasis is placed on evaluating variability and uncertainty. Variability is principally addressed by using the risk assessment model to evaluate a range of exposure assumptions that represent the different types of exposure conditions that may be experienced by different individuals who work, live and play in and around the Facility and in nearby communities. Calculations for this kind of sensitivity analysis are not provided in the attachments because the printing and organizing of the numerous model perturbations is considered infeasible.

As a technical report in support of an EIS, this report is oriented toward supplying information for scientists and engineers to use in developing the EIS. Therefore, the presentation is condensed, avoiding general descriptions of the risk assessment process.

1.3 PRIOR RISK ASSESSMENTS

1.3.1 Prior Risk Assessment in Support of the Permit Application

Holcim's application includes a human health risk assessment and a Screening Level Ecological Risk Assessment (SLERA) addressing the maximum anticipated change in risk associated with the proposed action. The risk assessment was performed to comply with the Administrative Rules of Montana (ARM 17.8.770), which requires that the change in risk from exposure to hazardous air pollutants (HAPs) associated with the proposed action be below negligible risk levels. Negligible risk is defined in ARM 17.8.740 as an increase in the excess lifetime cancer risk of less than 1×10^{-6} for any individual carcinogen, an increase in the excess lifetime cancer risk of less than 1×10^{-5} for the aggregate of all carcinogens, and an increase in the sum of the non-cancer hazard quotient (HQ) of less than 1.0.

The prior risk assessment in support of the permit application was based on emissions data for 13 other cement kilns that have measured stack emissions rates (in grams/second) before and after use of Whole Tires. These 13 facilities provide the known data available to support the assessment. The difference in emissions rates before and after use of Whole Tires was calculated for each HAP at each facility. For constituents with three or fewer data points (i.e. three or fewer facilities with measured emissions rates for a constituent before and after use of Whole Tires), the maximum difference in emissions rates was used to represent the estimated change in emission rates at the Holcim's Facility. If more than three data points were available, the lower of either the maximum value or the 95 percent confidence interval value was used to represent the maximum estimated emission rate for the Facility. Only data showing an increase in a constituent's emission rate after use of Whole Tires were used in the 95 percent upper confidence level calculations. Predicted COPCs emission rates resulting from the addition of glass, but not slag, into the kiln were included in the assessment.

Dispersion modeling software (AERMOD) used the predicted difference in emissions rates from use of Whole Tires to predict Ground-level ambient air concentrations at various locations of potential concern around the Facility. A California Air Pollution Control Officers Association (CAPCOA)-based model (CAPCOA 1993) was then used to estimate human health exposure and risk. A SLERA was also completed. The original application and risk assessment (Bison and Kleinfelder 2001) was extensively reviewed by the Montana Department of Environmental Quality (DEQ) and underwent public review and comment. All revisions resulting from the reviews were incorporated into the final permit application in 2004 (Bison and Kleinfelder 2004a).

The prior risk assessment in support of the permit application concluded that risks for the proposed action complied with the negligible risk rule. A Preliminary Determination on Permit Application (DEQ 2003) was prepared in response to the completed application.

1.3.2 Prior Risk Assessment in Support of the EIS

In response to DEQ's decision to complete an EIS addressing the proposed action, Holcim also prepared and submitted to DEQ - under their own initiative - both human health (Bison and Kleinfelder 2004b) and screening level ecological risk assessments (Bison and Kleinfelder 2004c). These risk assessments were prepared using the same emission inventory data for the 13 other facilities, the same AERMOD dispersion models, and the same risk assessment models that were used in the permit application. However, rather than assess risk based on the change in emission rates associated with the proposed action (as was done to support the permit application), risks were assessed based on total estimated emission rates before (i.e., baseline condition) and after (i.e., cumulative condition) use of Whole Tires.

The revised objectives of the new risk assessment in support of the EIS necessitated a different approach for using the emissions data from the 13 facilities. Because the previous risk assessment evaluated risks related to the difference in a constituent's emission rate before and after use of Whole Tires, data could not be used unless a constituent's emission rate was measured both before and after used of Whole Tires. Unfortunately, the facilities did not always measure the same list of HAPs before and after the use of Whole Tires. A second major difference was that the prior risk assessment was focused on evaluating risk for only those constituents that had positive increase in emission rates after use of Whole Tires for a facility, while the new assessment including data for constituents with reduced emission rates after use of Whole Tires.

For these reasons, the air emission rates, and accordingly the estimated risks for the baseline and cumulative conditions, cannot be directly compared to the change in risk determined in the risk assessment for the proposed action. In other words, one cannot subtract the baseline risk from the cumulative risk provided by the risk assessment done in support of the EIS and expect to get the same change in risk value that was determined in the risk assessment done in support of the permit application. The emissions data for the 13 facilities was used differently between the two risk assessments.

The risk assessment in support of the EIS concluded that human health risks for the cumulative condition (1×10^{-6}) were below risks for the baseline condition (3×10^{-6}). The human health hazard indexes (HIs) were 0.7 for the baseline condition and 0.5 for the cumulative condition. All HIs for all receptors in the ecological assessments were below 1.0. The highest HI in the ecological assessment was for the red-tailed hawk under the baseline condition (0.6).

The DEQ determined that an additional assessment prepared by the department was needed to support the EIS. This risk assessment satisfies that need.

1.4 EMISSION INVENTORY SUMMARY

This risk assessment relies on emissions inventory and dispersion modeling results developed in accordance with procedures described in a separate technical report (Lorenzen 2004). The ground-level air concentrations established in the Lorenzen report are used in this risk assessment to calculate multi-media (e.g., soil, water, food, and wildlife) concentrations and estimate risks. The ground-level air concentrations are presented in Attachment A. The principle emission inventory and dispersion modeling issues germane to both the human health and ecological risk assessments are summarized below.

1.4.1 Constituents of Potential Concern

ARM 17.8.770 requires that the risk assessment include an inventory listing potential emissions for all Federal Clean Air Act (42 USC 7401 et seq., 1970) HAPs. The emissions inventory addresses all HAPs for which data from other facilities was identified. This risk assessment therefore evaluates as constituents of potential concern (COPCs) only those HAPs included in emissions inventory and dispersion modeling.

Additional consideration was given to constituents of expressed concern by the public. A public scoping meeting was held in Manhattan, Montana, on January 20, 2004, to learn about public concerns with the proposed action. The concerns expressed (DEQ, 2004) were reviewed to identify COPC to the public. COPCs mentioned were: various metals (cadmium, chromium, lead, and mercury mentioned specifically), volatile organics, dioxin, and polycyclic aromatic hydrocarbons (PAHs). Each of these constituents is a HAPs for which emission data from other facilities was available to support this risk assessment.

1.4.2 Facility Upsets

For the purposes of this risk assessment, a Facility upset is defined as any condition that results in shutdown of the electrostatic precipitator (ESP). Under this condition, increased emissions would occur for constituents associated with particulate matter that would normally be captured by the ESP. The ESP removes particulate matter from the air stream. COPCs that are less volatile or otherwise tend to bind onto or within the particulate matter, such as most metals and less volatile organics constituents, are thereby also removed. Consideration of Facility upsets are quantitatively incorporated into the emissions inventories and dispersion models for long-term and short-term exposure. This approach precludes the need for a separate analysis addressing the upset condition.

1.4.3 Cement Kiln Dust

Cement kiln dust (CKD) is a byproduct resulting from cement production. The management of this material throughout the Facility is incorporated into the emissions inventory, dispersion modeling, and risk assessment for the long-term (chronic) exposure scenario. Short-term kiln upsets do not cause an instantaneous change in contaminant concentrations in the CKD, so modeling of acute (short-term) risks is limited to changes in kiln emissions only.

1.4.4 Glass and Slag

Glass has been evaluated in the previous risk assessments and will therefore continue to be evaluated in this risk assessment. Three HAPs, chromium and butylbenzylphthlate and di-n-butlyphthlate, exist in glass at higher levels than are known to exist in other existing fuels permitted for use. The emission rate estimates for these three HAPs are increased to reflect the use of glass.

In addition to glass, Holcim uses slag as a source of iron in the kiln. To support this risk assessment, DEQ incorporated slag use into the emission rate estimates. The incorporation of slag addition into the kiln resulted in increased modeled emission rate estimates for antimony, arsenic, chromium, cobalt, lead, manganese, nickel, phosphorus, selenium, and zinc.

1.5 RISK ASSESSMENT MODEL SELECTION

1.5.1 California versus EPA Models for Human Health Risk Assessment

The risk assessments conducted to date for the Facility have been completed in general accordance with the risk assessment methods developed by the CAPCOA Air Toxics “Hot Spots” Program (CAPCOA 1993). The risk assessment methods were developed specifically for use in evaluating risks associated with air emissions from industrial facilities. A revised risk assessment guidance document was published in August 2003 (California EPA 2003).

Several technical changes and updates were made to the 2003 risk assessment model. For example: the vine produce category was expanded to protected and unprotected produce categories, the weathering constant used to determine deposition onto produce was revised, several pollutant-specific default values such as fish bioconcentration factors and soil half-life were revised, and default assumptions such as the fraction of produce ingestion that is homegrown were added. The net effect of these and other changes on the overall protectiveness of the model is unknown, and is expected to vary depending on site-specific conditions.

The U.S. Environmental Protection Agency (EPA) has developed a Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 1998). While the

Holcim cement kiln is not a hazardous waste combustion facility, this protocol provides another established model which could be adapted for use in evaluating risk at the Facility.

There are numerous differences in how exposure is mathematically predicted between the California EPA and U.S. EPA models. There are no known quantitative comparisons of the relative risk levels estimated by the U.S. EPA and California EPA models. Some of the major differences between the two models and the implications to this risk assessment include:

- The California EPA model includes consideration of dioxin and polychlorinated biphenyl (PCB) exposure through mother's milk, while the U.S. EPA model does not. Otherwise, the food ingestion pathways are the same for the two models. The risks predicted by exposure to dioxin in mother's milk, under the assumptions incorporated into the California EPA model, frequently produces the highest source of risk to exposed individuals. The inclusion of this pathway may in many cases make the California EPA ore health protective then the U.S. EPA model.

- The U.S. EPA model considers wet and dry deposition from air to soil and water for all constituents, while the California EPA model only considers dry deposition for non-volatile constituents. Also, the EPA model considers runoff from soils to water during rainfall, which is not included in the California model. The inclusion of COPC transport pathways for wet deposition adds a substantial number of additional calculations to the model. Because of the dry nature of the area surrounding the Facility, the effect of wet deposition on soil concentrations is expected to be small relative to that predicted by dry deposition. Concerning predicted surface water concentrations, most of the water in the Missouri River is derived from unaffected upgradient sources. There is minimal soil-to-water runoff from the area under investigation that may potentially impact flow and water quality. Therefore, little benefit would be derived for this project from the extra COPC transport pathways included in the U.S. EPA model.

- Two important factors affecting predicted COPC soil concentrations are the assumed depth into which COPCs are expected to mix in soil and the bulk density of the soil. The U.S. EPA assumes a 20 cm mixing depth for tilled agricultural, a mixing depth of 1 cm for untilled soil, and a soil bulk density of 1500 kg/m^3. The California EPA model assumes a 15 cm mixing depth for all food related pathways (regardless of tilling practices), a mixing depth of 1 cm for direct contact pathways, and a soil bulk density of 1300 kg/m^3. There are many other factors in each of the models, some of which are constituent specific, that complicate this comparison. However, all else being equal, the U.S. EPA factors identified will result in lower predicted COPC exposure then would be predicted if using the California EPA factors. On balance, the California EPA model is likely to predict higher levels of COPC exposure.

- The California EPA model includes stochastic methods for assessing population variability (California EPA 2000) that are not included in the U.S. EPA model. The unavoidable uncertainty and variability in performing a risk assessment can result in a range of opinions about the correct model input factors to use in the risk assessment. Stochastic approaches for estimating risk can be used to more fully disclose the potential risk implications of various model input assumptions. This mathematical approach allows ranges of values to be used for specific model inputs that are based on the known inherent variability. Using Monte Carlo simulation methods, these ranges of input values are propagated through the model to produce a range of risk estimates rather than a single risk estimate. The availability of an agency approved protocol for evaluating and presenting variability in risk using stochastic methods allows the California EPA model to be more effective in evaluating and communicating risk results.

In summary judgment, the California EPA model is less mathematically complex and more likely to produce risk estimates for this project that are more health protective. The California model also provides the added benefit of approved model inputs for stochastic analysis for evaluating and communicating variability in exposure and risk. This risk assessment uses the updated California guidance (California EPA 2003) to construct a spreadsheet-based model. The risk assessment spreadsheet model was developed independently. It does not use electronic information contained in previous risk assessments submitted by Holcim.

1.5.2 EPA's Lead Model

The U.S. EPA has developed an approach for evaluating risk from exposure to lead that is different from other constituents. For lead, subtle neurological changes have been correlated with blood-lead concentration. Children are believed to be most susceptible. The EPA has developed the Integrated Exposure and Uptake Biokinetic Model (IEUBK) for lead in children (EPA 1994a, 2004a), which estimates blood-lead levels based on multiple routes of exposure. The IEUBK is used in this assessment.

1.5.3 Ecological Risk Assessment Models

The State of California has not developed guidelines for evaluating ecological risk within the “Hot Spots” program. The U.S. EPA has developed a Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 1999a). This guidance essentially adopts the same fate and transport models for estimating environmental concentrations for constituents that are used in EPA's human health guidelines (EPA 1998), but provides additional guidance related to ecological receptor selection, bio-uptake modeling, toxicity assessment, and risk characterization. Similarly, this assessment generally uses the California EPA models for estimating environmental concentrations for constituents, and the EPA (1999a) guidance for evaluating other relevant aspects of the ecological risk assessment.

The ecological risk assessment model developed for this assessment is derived from an electronic version of the SLERA previously submitted to DEQ by Holcim (Bison and Kleinfelder 2004c). Many revisions were made however. Major changes include selecting toxicity factors from different sources in many cases, revised methods for calculating body burdens, inclusion of deer as a new receptor in response to expressed public concern about game species, and inclusion of additional COPCs such as methyl mercury. The incentive behind these changes is to supply new and independent perspective of the potential ecological risks. A comparison of the results of this ecological risk assessment with the previous ecological risk assessment provided by Holcim in support of the EIS can provide a range of understanding regarding the potential ecological risks.

2. HUMAN HEALTH RISK ASSESSMENT

The first three sections of the human health risk assessment (Sections 2.1 to 2.3) are focused on explaining the basis for the quantitative evaluation. Section 2.1, Exposure Assessment, evaluates the fate and transport of constituents in the environment and establishes the routes by which people may be exposed to the constituents. For each exposure scenario calculations are made regarding the exposed dose, which is expressed as milligrams of constituent ingested per kilogram body weight per day (mg/kg/day). Section 2.2, Toxicity Assessment, identifies quantitative measures of toxicity for each COPC that are comparable to the dose. Section 2.3, Risk Characterization, calculates risk by comparing exposure under the various exposure scenarios to toxicity.

More qualitative aspects of the assessment are addressed in Section 2.4, Uncertainty and Variability. Section 2.5, Summary and Conclusions, integrates both the quantitative and qualitative aspects of the risk assessment into a concise summary in support of informed risk management decision-making.

2.1 EXPOSURE ASSESSMENT

This exposure assessment describes how constituents emitted from the facility are transported through the environment, and it identifies the types and magnitudes of exposure that are occurring or may plausibly occur in the future. An exposure pathway defines the mechanisms by which a constituent comes into contact with a person. A complete exposure pathway requires all of the following:

- A source of release into the environment
- A transport mechanism for constituent release and migration from the source
- Contact with a receptor
- A mechanism for constituent intake into the body.

Figure 2-1 provides a conceptual model illustrating the fate and transport of constituents in the environment upon release from the Facility. The rationale supporting the conceptual model is described in the subsections that follow. How the conceptual site model is used to identify relevant equations and input assumptions in the risk assessment model is also explained. The approach used is to integrate site descriptions with descriptions about how exposure is quantitatively evaluated. Not all details of the quantitative model are discussed. Rather, emphasis is placed on describing those areas of the model where site-specific considerations are required as inputs to the model or where site-specific considerations result in deviations from default assumptions contained in the model.

2.1.1 Emission Sources and Primary Transport Mechanisms

Two types of emissions from the Facility are evaluated in this assessment: stack emissions and fugitive emissions resulting from CKD management. The stack location is shown on

Figure 2-2. Chemicals in the gas stream within the stack are either in gaseous form or are associated with particulate matter. The gas stream is normally treated using an ESP, which removes a vast majority of the particulate matter and the constituents associated with the particulate matter. The gas stream is then released from the stack at a height of 39.62 meters.

The ESP operation is occasionally interrupted due to unpredictable causes such as fuel feed rate problems and equipment malfunction, resulting in uncontrolled particulate emissions. Increased particulate emissions resulting from assumed ESP upset duration and frequency are integrated into emissions estimates used in this assessment.

CKD is the particulate matter removed from the gas stream by the ESP. CKD is managed on-site in various ways that can release small amounts of fugitive dust. This assessment considers CKD emission from: dust discharge from the end of the kiln, dust discharge during silo loading and unloading, road dust emissions, dust generated during material spreading and material dumping operations, and windblown dust from piles.

Once emitted, the dispersion of COPCs is dictated by wind speed and direction. A wind rose describing prevailing wind directions and speeds based on a meteorological station at the Facility is provided in Figure 2-2. The facility is located on the banks of the Missouri River where the river flows into a canyon. The wind rose indicates that predominant local wind direction is from the southwest to northeast, following the river canyon. On average and over the long term, ambient air concentrations of emitted COPCs are expected to be greater downwind of the Facility.

The methodology for estimating emission rates and conducting the dispersion modeling is described in detail in a separate technical report (Lorenzen 2004). In summary, emission rates for all HAPs except dioxin are based on data provided by Holcim regarding measured emissions before and after use of Whole Tires at 13 other cement plants nationally (Bison and Kleinfelder 2004a). Dioxin is the only constituent-specific HAP with a federally mandated emission limit applicable to the Facility[1]; therefore, dioxin emissions are based on U.S. EPA Portland Cement Maximum Achievable Control Technology (PC-MACT) emission limits for dioxin.

Numerous differences between cement plants can affect HAPs emission rates, such as kiln type, combustion temperature, fuel type, stack height, oxygen content, type of emission control equipment used, and other variables. As a check on the validity of the emission rate estimates, stack testing at the Facility was conducted in 2002 and 2003 for dioxins/furans, PAHs, hydrogen chloride and 12 metals (including lead, mercury and arsenic). The stack test results were compared to the estimated emission rates for the cumulative condition and to emissions estimated using AP-42 factors. Dioxin/furan results

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[1] More specifically, EPA (1999b) established emission limitations for particulate matter (as a surrogate for HAP metals), dioxins/furans, and total hydrocarbons (as a surrogate for organic HAPs, including polycyclic organic matter). Emission rate limitations for these parameters are incorporated into DEQ's Preliminary Determination on Permit Application (DEQ 2003).

were compared to the PC-MACT limit. This comparison indicated that the emissions estimated for the cumulative condition exceeded test data results and that Dioxin/furan emissions are less than the PC-MACT limit (Lorenzen 2004, Appendix C). These findings provide a measure of confidence that the emission rate estimates using in this assessment conservatively estimate future potential emission rates at the Facility.

The emission rates used in this risk assessment are corrected to account for ESP upset using an upset multiplier. The upset multipliers used to estimate the annual average emission rates are derived based on an average of 81.6 hours per year of upsets, an estimated 99.4 percent particulate removal efficiency, and estimates for the percent of the emissions that are associated with particulate (100% for metals, 20 percent for dioxin/furans, and 5 percent for mercury, hydrogen fluoride and hydrogen chloride). The upset multipliers for the 1-hour peak emission rates use the same assumptions, but also assume as a reasonable worst case assumption that the upset lasts for 30 minutes. The average length of an upset was 13.2 minutes. Values for particulate removal efficiency, the percent of emissions associated with particulate, and upset duration were obtained from information submitted by Holcim (Bison and Kleinfelder 2004a). Metals derived from slag use were assumed to partition 95% into clinker and 5% to the ESP (i.e. stack emissions and CKD). The formulas used are provided in Appendix A.

Ground-level air concentrations at various receptor points surrounding the Facility are estimated from stack and CKD emission rates using an air dispersion model (AERMOD). The dispersion model incorporates a variety of climatic variables, such as wind speed and direction. The modeling addresses 80 COPCs. CKD is expected to contain 17 of the COPCs which have the type of physical/chemical characteristics that would cause them to sorb with particulate matter in the stack. Ground-level air concentrations for COPCs in the CKD are determined using individual model runs with three CKD emission points plus the kiln. Ground-level air concentrations for COPCs not in the CKD are modeled using only the kiln stack emission point.

Dispersion coefficients are generated by the AERMOD model runs for each receptor point. The dispersion coefficients are expressed in units of micrograms/cubic meter per grams/second [($\mu g/m^3$)/(g/sec)], which is defined as χ/Q (chi over Q) with χ representing the ground-level concentration and Q representing the kiln emission rate.

The calculations for determining annual average ground-level air concentrations for the highest modeled receptor points (for the 1-hour acute and 1-year chronic conditions) are provided in Attachment A. The dispersion coefficients determined for key receptor locations used in this human health risk assessment are shown on Figure 2-2.

2.1.2 Secondary Transport Pathways and Affected Media

2.1.2.1 Deposition

Once in the air, constituents are released onto soil, water, and vegetation (animal forage and human food crops) through wet and dry deposition. Different constituents will deposit at different rates depending on certain physical characteristics such as vapor pressure (i.e., volatility), tendency for particulate sorption (either during emissions or from particulate binding after emissions), climatic conditions, and other variables.

California EPA guidance (2003) assumes that volatile emissions are not deposited onto land to a significant enough degree to warrant inclusion of the pathway. Also, California EPA guidance does not account for wet deposition processes, even though wet deposition (during rainfall) has the potential to remove constituents from the air much more quickly. Given the dry nature of the area surrounding the Facility, excluding this pathway is not believed to substantially underestimate deposition over the long term.

California EPA guidance (2003) assumes an average dry deposition rate for all non-volatile constituents of 0.02 meters/second for controlled sources (applicable for emissions containing less than 2.5 microns) and 0.05 meters/second for uncontrolled sources. A higher deposition rate is used for uncontrolled sources because of the increased particulate matter associated with untreated air emissions.

These default assumptions are supported by general knowledge of emission characteristics of cement kilns generally. Section 7 of Risk Burn Guidance for Hazardous Waste Combustion Facilities (EPA 2001) states:

> "For cement kilns equipped with ESPs or fabric filters, a technical support document to the hazardous waste combustor MACT rule uses a particle-size mass distribution estimate of 50% < 2.5 microns and 85% < 10 microns. This distribution compares favorably with the distribution provided in Table 7-2 for sources equipped with ESPs or fabric filters. The estimate is based on the distributions for Portland cement kilns provided in AP-42 of 45 to 64% < 2.5 microns and 85% < 10 microns, as well as distribution data for three hazardous waste burning cement kilns ranging from 50 to 75% < 2.5 microns and 70 to 90% < 10 microns."

This assessment uses the 0.02 meters/second deposition rate, even though the upset emissions (when the ESP is offline) are integrated into the emission estimates. This is not believed to substantially affect deposition estimates because the ESP is only offline a small percent of the time (81.6 hours per year based on Facility data for 2000 and 2001; see modeling results using recommended inventory in Attachment A). While a substantial portion of the metals released to the ambient environment are estimated to result from upset conditions, the particle sizes of metals are generally small. On Page 161 of the Risk Burn Guidance for Hazardous Waste Combustion Facilities, EPA (2001) states, "The larger particles were shown to be porous, carbonaceous cenospheres resulting from poor carbon burnout." Therefore, use of the controlled deposition rate as a simplifying assumption applicable to all sources of emissions is deemed appropriate.

As shown in Attachment A, consideration of the upset condition (described in Section 2.1.1) affects the annual average ground-level air concentrations for metals much more than other parameters. Annual kiln emission rates for particulate metals, including periods of uncontrolled emissions due to upset conditions, are estimated to be 2.54 times higher than the fully controlled annual emission rate. Emission rates for dioxin/furans are 1.31

times higher when upsets are factored in and emissions of mercury, hydrogen fluoride and hydrogen chloride are 1.08 times higher.

2.1.2.2 Soil Accumulation

Continued deposition onto soils over a long period of time may contribute to accumulation. In general terms, the rate of accumulation is dependent on the physical characteristics of both the constituents and the soil, and other site factors like stormwater runoff and leaching to groundwater. Runoff into surface soil and soil to groundwater leaching are pathways that are not addressed by California EPA guidance. Accordingly, many of the constituent characteristics that would affect the transport of constituents into other media are not accounted for in the model. This is not believed to be a major factor at this site because of the dry nature of the area.

Natural degradation is accounted for in the model based on estimates of the soil half-life. Attachments B-1 and C-1 show, for baseline and cumulative conditions respectfully, the calculations used to determine soil concentrations and graphically show how concentrations for select parameters vary over time. Metals have the longest half-lives. Considering lead in the baseline condition for example, predicted soil concentrations after 70 years of deposition (4.7021 mg/kg) are about seven times greater than after 10 years of deposition (0.6428 mg/kg). The increase over time is less for organic constituents, which have shorter half-lives. For example, PAH concentrations are predicted to increase for the first ten years, after which concentrations remain constant.

Because soil concentrations change over time, the selection of the time interval used in the risk assessment can affect the resulting estimates of risk. California EPA (2003) default assumptions consider a 70-year time period for determining soil concentrations, and U.S. EPA (1998; Table B-1-1) suggests 100 years “unless site-specific information is available indicating that this assumption is unreasonable.” This assessment uses the average concentration over a 100-year period of Facility operation as the soil concentration input value for COPCs throughout the risk assessment.

Consistent with California EPA (2003) guidance, residential soil concentrations are used for the soil ingestion and dermal pathways. Residential soil concentrations are based on a model default soil depth value of 0.01 meters. Lower soil concentrations for agricultural pathways (produce and animal products) are used based on the model’s default soil depth value of 0.15 meters.

2.1.2.3 Water Concentrations

Wet and dry deposition processes may also result in the addition of constituents into surface water, although only the dry deposition pathway is included in the California EPA model. Water bodies may also receive constituents from stormwater runoff and discharge of any contaminated groundwater into surface water. Methods for estimating constituent transport by these mechanisms are not included in the California EPA model. Exclusion of these pathways is not expected to affect the predicted concentrations in water significantly because of the dry nature of the area.

The area surrounding the Facility contains rivers, wetlands, and lakes. It is plausible that privately constructed ponds also exist in the area or could be constructed in the future. Therefore, this assessment quantitatively assesses dry deposition into both rivers and lakes.

River Water Concentrations. For rivers, dispersion modeling was performed in a broad area along the waterways of concern. Receptor locations were selected along the river to represent 0 to 10-km and 10 to 25-km stretches of river in all directions, as shown on Figure 2-2. This distance from the Facility accounts for most of the total air mass of constituents that are available for deposition. More distant X/Q values in all directions are orders of magnitude below the worst-case location value (0.29355).

An estimate was made of the total surface area within the 25-km radius that is covered with water. The estimation was made by using Geographic Information System (GIS) layers and attribute tables from: "USGS National Land Cover for Montana, Vector Format" (http://nris.state.mt.us/nadi/nris/nlcd/nlcdvector.html, derived from 30-meter Landsat thematic mapper data), and "Montana 1:250,000 Scale Land Use from USGS" (http://nris.state.mt.us/nsdi/nris/lu25/lu25s.html, derived from U.S. Geographic Survey [USGS] Geographic Information Retrieval And Analysis System [GIRAS] files).

Within 10 km upstream of Trident, both data sources show open water (including streams, reservoirs, and wetlands) as being approximately 1 percent of the total surface area. When the analysis area is a doughnut-shaped area extending from 10 km to 25 km in all directions (which is close to Toston), open water goes down to approximately 0.1 percent of the total surface area, and streams/canals comprise about 0.035 percent of the area, the remainder being in wetlands and reservoirs. This assessment assumes 1 percent of the landmass as rivers within 10 km; assuming that ponds and wetlands in the Three Forks area are hydrologically connected to the river system. Rivers that are beyond 10 km are assumed to comprise 0.035 percent of land mass.

To calculate water concentrations, estimates of water volume for the various river segments and the number of times the water volume changes or is turned over per year are required. Water volume in a given river segment is estimated based on USGS flow rate and mean velocity data, determined as follows:

$$\text{Flow (Q)} = \text{Velocity (v)} \times \text{Cross-Sectional Area (A)}$$

or, upon rearranging,

$$A = Q/v$$

Since Volume (V) equals the Cross-sectional Area (A) times the Length of River (L), solving for A and substituting in the above equation provides:

$$V/L = Q/v$$

or,

$$V = Q/v \times L$$

Stated verbally, the volume of water in a segment of river represented by a receptor equals the quotient of the flow rate divided by the mean velocity times the river segment length.

Volume changes are based on USGS flow data. A review of the GIS layers indicates that the winding river flow length is approximately twice that of linear distance between two river points. For example, there is 20 km of river length from 0 to 10 km downstream of the Facility. Additional details about the calculations are explained and the results presented in the water concentration calculations (Attachment B-2 for baseline condition; Attachment C-2 for cumulative condition).

The risk assessment selects the most downgradient receptor point for evaluation. The approach used very conservatively assumes no loss of COPCs as the water moves downstream. Stated differently, upgradient stream reaches already receive COPCs before the water moves into the next downstream reach where additional COPCs are received. Therefore, the final river concentration for a COPC is the sum of the predicted river concentrations for that COPC in each stream reach.

Lake/Pond Water Concentrations. Calculations to predict water concentrations in lakes are not nearly as complex. However, numerous lake or pond locations and configurations can be conceived that will affect the predicted concentrations of COPCs.

The Three Forks Area has the highest air dispersion coefficient values in the valley region located south of the Facility. The area presumably has many oxbow and/or pothole ponds. Private ponds may also be located in the area. Accordingly, the dispersion coefficient value for Jefferson 2 (X/Q = 0.00559) was selected to evaluate risks in ponds. Additionally, the water concentration calculations for the cumulative condition (Attachment C-2) were modified to consider a 100,000-gallon pond, as follows:

- Surface area is 126 m^2 and depth is 3 m, for a volume of 378,501 liters.
- Volume change is set to one change over per year. No buildup of water concentrations as a result of multi-year emissions was accounted for, under the assumption that all lakes and ponds regularly receive fresh water inputs.

Selecting a shallow pond with little change over leads to predicted COPC concentrations that are strongly biased toward a maximum likely concentration. Locating the pond further downriver and closer to the stack will increase predicted COPC concentrations, while locating the pond further upstream and away from the stack will decrease predicted COPC concentrations. Keeping the pond equidistant from the stack, but moving it away from the upwind direction from the stack will result in higher predicted COPC concentrations in the water.

2.1.2.4 Concentrations in Food Products

The land around the Facility is arid grassland. Ongoing and future potential typical site use includes grazing, grain production, and wildlife use.

Default model assumptions were used wherever possible to estimate the concentration of COPCs in the edible portions of a wide range of food products. California EPA (2003) guidance recommends a default value of 50 percent for the percent of feed obtained by grazing for beef and dairy cattle. However, the more health protective default values provided by EPA (1998) guidance were used. Beef cattle are assumed to obtain 75 percent of feed from grazing, and dairy cattle are assumed to obtain 65 percent of feed from grazing. California EPA guidance also did not provide a specific method for calculating COPC concentrations in forage; consequently, soil to forage transfer coefficients provided by EPA (1998) guidance were used. Animals were assumed to obtain drinking water from the point of highest impact on the Missouri River.

2.1.2.5 Sediment Concentrations

Once in the water, constituents can further partition into aquatic sediments. Minimal exposure of people to river, lake or pond sediments is expected. People are mostly likely to be exposed to COPCs in sediments while swimming or wading (without the use of waders). This kind of activity can only be done during the summer, and expect for the warmest of ponds, can only be done for limited amounts of time. Any exposure via this mechanism is expected to be very small relative to other routes of exposure included in the human health risk assessment. Quantitative estimates of COPC concentrations in sediments and the corresponding assessments of risk are therefore not provided.

2.1.3 Existing and Potential Receptors

The Facility is located in a rural area. Nearby communities are shown on Figure 2-2. Much of the area surrounding the Facility is private land. While agriculture is likely to be the predominant site use in the area for the foreseeable future, residential development could occur. Also, the area supports a good abundance of fish and wildlife that provide recreational fishing and hunting opportunities for the general public. The Three Forks Area is an important landmark in the Lewis and Clark expedition, attracting tourists to the area.

Based on site knowledge and expressed public concern, four general types of exposed population groups (termed receptors) are included in this assessment: Holcim workers, existing residents, future potential residents, and recreational site users. The California EPA model evaluates residents as a time-weighted exposure during childhood and adult years. Within each general category there is variability of individual behavior. Some blending of these four general types of receptors is done to ensure that reasonable maximum exposure conditions are represented in the assessment and to support a quantitative assessment of population variability in exposure and risk. The subsections that follow explain the rationale supporting the approach used for evaluating receptor exposure and risk. Important model inputs for quantitative exposure assessment are also identified.

2.1.3.1 Short-Term Exposure by Holcim Workers and Residents

Employees and contractors who work at the plant site are exposed to Facility emissions. While working, workers are exposed to contaminants in air and soil. Other pathways of exposure (e.g., food, surface water, sediment, and groundwater) may occur on a limited basis; however, these pathways are evaluated much more conservatively (i.e., in a more health protective manner) for residential receptors. Similarly, long-term exposure to air and surface soil are addressed more conservatively for the residential pathways. Therefore, for workers this assessment focuses on assessing short-term exposure via inhalation. Worker exposure is typically evaluated based on an 8-hour work day, with additional consideration given to peak concentrations immediately dangerous to health.

While Facility emissions rates remain fairly constant during operations, ground-level air concentrations can vary due to changes in climatic conditions. Varying climatic conditions can create short-term concentrations that are much higher than annual average concentrations. High concentrations over the short-term may create potential acute risks to both workers (on Holcim property) and future potential residents (off Holcim property). Consistent with both U.S. EPA (1998) and State of California guidance (California EPA 2003), acute risk to human health is evaluated for the location with the maximum modeled 1-hour concentration.

For this project, the maximum 1-hour concentration is located off Holcim property along an adjacent hillside at approximately the elevation of the stack (Figure 2-2). Therefore, standards appropriate for residents and the general population are used to evaluate potential toxicity. While workers are assumed to be generally healthy adults, the general population can include individuals with potentially greater susceptibility to adverse effects from exposure to contaminants. Therefore, the toxicity factors used to evaluate off-site acute exposure are potentially lower for some constituents than standards for protection of workers. The use of higher exposure concentrations and potentially lower toxicity factors for evaluating hazards at the point of maximum 1-hour concentrations results in a worst-case assessment of risk that is protective of both workers and residents. Therefore, short-term hazards to workers are not assessed directly, but may be inferred to be equal to or less than the estimated hazards for the worst-case location.

2.1.3.2 Existing and Future Potential Long-Term Residential Exposure

Existing and future potential residents are of greatest concern regarding long-term potential exposure to COPCs. Long-term worker exposure and risk is expected to be less then residential exposure in this assessment for several reasons:

- Compared with worker exposure, residential exposure considers exposure to children and adults. The default assumptions used to estimate exposure result in greater predicted levels of exposure in children then in adults, thereby resulting in greater risk estimates for residents.

- Residential exposure assumptions involve longer exposure frequencies, longer exposure durations, and include a larger number of exposure pathways such as food and drinking water pathways. These assumptions result in increase exposure and risk for residents.

- Kiln stack emissions disperse away from the center of the facility due to stack height, exhaust temperature and plume momentum. COPC concentrations resulting from the kiln emissions are expected to be greatest at elevated terrain that could be impacted by the plume, as represented by receptors along the property boundary and beyond. Exposure to COPCs from CKD is greatest within the plant area, but is significantly less than exposure due to kiln stack emissions.

Because residential exposure is only expected to occur outside the Facility, long-term exposure only considers off-Facility property areas. Two general categories of residents are evaluated, existing residents in nearby communities (Three Forks, Belgrade, and Manhattan) and future potential residents at the location of maximum impact (the property boundary for the Facility as shown on Figure 2-2). Getting all of one's food from one location is consistent with a subsistence lifestyle scenario. While recognizing that the future potential for someone to engage in a subsistence lifestyle adjacent to the Facility is remote, this scenario is included to provide an assessment of the absolute worst-case exposure scenario. Evaluating each of these different types of residential receptors provides an understanding for how risk varies with distance in different directions from the Facility.

Consistent with California EPA (2003) guidance, long-term exposure is evaluated based on the dispersion modeling results for the annual average constituent concentrations in air at ground level. Ground-level air concentrations are used to predicted constituent concentrations in air, food products, surface soil, and surface water. Minor exposure pathways are not evaluated. Exposure to constituents in aquatic sediment is possible, but predicted concentrations are much lower than in surface soils. Similarly, any potential groundwater contamination is expected to be much lower than predicted surface water concentrations. Moreover, methods for determining groundwater concentration are not included in the California EPA model (presumably because exposure via this pathway does not typically make a significant difference to total exposure). Accordingly, exposure to constituents in sediment and groundwater are not quantitatively evaluated.

Existing residential exposures within established communities are predicted based on the ground-level air concentration at the closest receptor point to that community. The ground-level air concentration also affects exposure via dermal and incidental soil ingestion pathways. However, existing community residents may obtain water and food products that are raised (at some hypothetical future time) at the worst-case annual average location. In this way, exposure via inhalation, soil ingestion, and dermal adsorption is separated and evaluated independently from exposure via other food pathways.

Individuals within a community will experience varying degrees of exposure. Examples of factors that influence this variability include: distance from the Facility, factors affecting incidental soil ingestions such as cleanliness, pica (i.e., childhood soil ingestion) tendencies, body weight (into which a given exposure is averaged to determine dose), food ingestion preferences, and many others. Therefore, exposure estimates are provided to represent an average type person’s exposure and a high-end estimate of a person’s exposure. Furthermore, a full distribution of individual variability for certain model input parameters are used to support a stochastic analysis. The stochastic analysis is performed using Crystal Ball software. To minimize controversy, the stochastic analysis is limited to only those model input factors supported by California EPA guidance (2003). The distributions used in the model are shown in the Crystal Ball reports in Attachments B-4 (baseline condition) and C-4 (cumulative condition). The same distributions are used in each case.

2.1.3.3 Recreational User

Various recreational opportunities exist in the area surrounding the Facility, such as fishing, hunting, swimming, and dirt biking. Public concern was expressed (DEQ 2004) regarding potential health effects from consumption of potentially contaminated fish and game. This assessment therefore quantitatively evaluates risks resulting from consumption of locally caught fish and game products.

Activities like swimming and dirt biking can result in increased contact with COPCs in soil and water. Exposure to COPCs via the drinking water pathway is included in this assessment. In comparison to drinking water, swimming will provide only marginally increased levels of exposure. Dirt biking and other activities that result in unusually high levels of soil contact are likely to result in increase exposure to COPCs. The soil ingestion rates used in this assessment represent reasonable worst case soil ingestion rates for individuals within a community over an extended period of time. A variety of high and low soil contact activities affecting soil ingestion rates are inherent to the default soil ingestion rates used in this assessment. However, the extent to which an individual engages frequently in an activity that results in high levels of contact with impact soil, risks can be qualitatively understood to be higher than those predicted by this assessment.

Fish Exposure Assumptions. This risk assessment endeavors to include those individuals who may catch and consume large amounts of fish in the area around the Facility. No studies of fish consumption rates in Montana are known. The California EPA (2003) default assumption for high-end fish consumption is 1.35 grams of fish per kilogram of a person’s body weight per day. Expressing fish consumption by kilograms body weight allows the model to integrate exposure over a lifetime, considering ingestion during both childhood and adult years. The default assumption rate is equivalent to 74 pounds of fish per year for an adult (average adult body weight is 70 kilograms). This value is believed to be reasonably protective of a resident who catches and consumes fish locally on a frequent basis.

Venison Exposure Assumptions. Risks from consumption of deer that graze in the area around the Facility are assessed using the default model for the cumulative condition, modified as follows:

- Ground-level air concentrations for COPCs are averaged for a region around the Facility, per the methodology used in the Ecological Risk Assessment (Section 3.1.1.2).

- Inhalation, water ingestion, and feed ingestion rates established in California EPA guidance for cattle were modified to reflect the appropriate assumptions for deer. The rates are the same ones used for deer in the Ecological Risk Assessment (inhalation 13.76 m^3/day; water ingestion 3.7 l/day; feed ingestion 1.74 kg/day).

- The diet of a deer is assumed to be 100 percent from grazing, rather than the EPA default values of 75 percent grazing and 25 percent feed that are used for cattle.

- The same transfer coefficients used to predict meat concentrations from feed concentrations for cattle are used for deer. Biouptake and accumulation is largely controlled by the lipophilic (fat solubility) characteristics of individual constituents. As game has less fat than domestic animals, the assessment of ingestions through domestic animal ingestion is expected to be protective of game ingestion.

Human food ingestion rates based on beef consumption were not changed for the assessment of venison consumption. In particular, the assessment assumes a high-end consumption rate for venison of 6.97 grams per kilogram body weight per day. For an average 70-kilogram adult, this equates to 1.07 pounds of venison ingested per day or 391 pounds per year. In the absence of any known studies of game ingestion rates in Montana, the high-end meat consumption rate is believed to be protective of an individual who subsists largely on locally hunted game. The average exposure assumes 126 pounds of venison consumed per year.

2.1.4 Chronic Exposure to Lead

Concentrations of lead in blood have been used extensively in evaluating lead toxicity. Accordingly, EPA has established a methodology for evaluating exposure to lead based on predicting blood-lead levels (EPA 1994a). Since children are considered to be more sensitive to lead exposure, EPA’s IEUBK model estimates blood-lead concentrations in young children (six years of age and younger) based on multimedia exposure (e.g., air, food, water, soil, and alternate media).

The EPA’s model includes default values for exposure to lead in food, air, and water. These background levels are based on national studies of the distribution of lead contamination in these media. This assessment substitutes the model’s default values for food and air with site-specific values predicted using the exposure assessment described above for the worst-case future potential residential scenario. Background levels of water in the EPA’s default model are mostly associated with lead used in solder of older plumbing. Since older plumbing in the study area may contain this source of lead, the additional lead obtained from predicted surface water concentrations is added to this background level. Site-specific soil lead concentrations for the worst-case annual average location are also included in the model.

2.2 TOXICITY ASSESSMENT

This section describes the approach used to evaluate the toxic properties of contaminants of potential concern. A fundamental principle of toxicology is that dose determines the toxic properties (or perhaps nutritional benefit) of a constituent. The toxic properties of a constituent can change depending on the dose received. Accordingly, toxicity factors (cancer slope factors for carcinogens and chronic reference doses for systemic toxins) have been developed by the EPA to support quantitative risk assessment.

2.2.1 Cancer Slope Factors

A cancer slope factor is the upper bound estimate of the probability of a cancer response per unit intake of a constituent averaged over a lifetime. It is derived based on the relationship of exposure (dose) to cancer rates (response) in laboratory studies using animals or epidemiological studies of human exposure. Various statistical regression methods are used to evaluate the dose versus cancer rate data and calculate the slope factor. Once established, the slope factors are used to extrapolate the observations in experimental studies to lower levels of exposure typically observed in environmental investigations such as this one.

It is not conclusively known whether the relationship between dose and cancer rates observed in experimental studies is preserved when extrapolated to much lower concentrations typically observed at project sites such as this one. The development and use of slope factors for risk assessment is a policy position by the EPA in the absence of complete scientific information. The slope factor is typically set at the 95 percent upper confidence level of the dose-response relationship to provide a margin of safety against the unknown. However, the EPA has long acknowledged that actual toxicity may be much lower, and may be as low as zero (EPA 1986).

2.2.2 Chronic Reference Doses

All toxic effects other than cancer are evaluated using a reference dose approach. Unlike the cancer slope factor, implicit in the use a reference dose is that there is a concentration below which no toxic effects are known to occur. Uncertainty factors are used to make toxicity factors more protective when confronted with uncertainty, such as extrapolating observed experimental results in animals to potential effects in people. Reference doses are developed based on both acute (short-term) and chronic (long-term) exposure. Generally, as the exposure period of interest gets longer, the value of the chronic reference dose becomes lower relative to the acute reference dose. Reference doses are intended to be protective of the most sensitive adverse effect known, and provide margins of safety against the unknown.

This assessment applies the most current toxicity factors developed by the EPA. Cancer slope factors and chronic reference doses developed by the State of California are not used. The slope factors and chronic reference doses used in this assessment are presented in Attachments B (baseline condition) and C (cumulative condition). The same factors are used in both assessments. The EPA toxicity factors were obtained from the Integrated

Risk Information System (IRIS) at www.epa.gov/iris. Chemical specific information regarding toxicity characteristics and the basis for development of the toxicity factors are described on IRIS.

2.2.3 Acute Reference Doses

The State of California has developed acute reference dose values (California EPA 1999) specifically for comparison with exposure estimates determined using the California EPA exposure model applied in this risk assessment. This assessment uses the acute reference doses developed by the State of California where they are available for the 1-hour exposure duration. Various other sources of acute reference doses are used as necessary in order of priority as recommended by EPA guidance (1998). In a few cases, standards developed for application to the general population were not available. In these cases, OSHA standards, applicable to workers over an 8-hour work day, were used. By comparing 1-hour exposure concentrations to the 8-hour standard, a margin of safety is integrated into the assessment. The acute reference doses used in this assessment are provided in Table 2-1.

2.3 RISK CHARACTERIZATION

This section of the report presents the quantitative results of the human health risk assessment. The methodology used to calculate risks is described in Section 2.3.2. The quantitative results of the human health risk assessment are presented beginning with Section 2.3.3.

2.3.1 Methodology

In the most general sense, risks are quantified by comparing exposure rates quantified in Section 2.1 with the quantitative toxicity factors presented in Section 2.2. The mathematical approach used to quantify risks from chronic exposure to carcinogens is different from the approach used to quantify other types of hazards.

2.3.1.1 Carcinogenic Risk

For carcinogenic constituents, an estimated excess lifetime cancer risk is calculated using:

$$\text{Risk} = I \times SF$$

where:

I = Chemical Intake; the estimated exposure level in mg/kg/day averaged over a lifetime

SF = Slope Factor; the upper bound estimate of the probability of a cancer response per unit intake of a constituent averaged over a lifetime in 1/(mg/kg/day).

All carcinogenic risks are reported to only one significant figure, consistent with the inherent level of accuracy of a risk assessment.

2.3.1.2 Guidelines for Acceptable Risks

ARM 17.8.740 defines a negligible risk for carcinogens as an increase in the excess lifetime cancer risk of less than 1×10^{-6} for any individual carcinogen and 1×10^{-5} for the aggregate of all pollutants. This standard is intended to apply to the change in risk associated with the change in emissions resulting from the incineration activities. It does not necessarily apply to the total risk from all Facility emissions.

Regarding constituent spills onto soil and water, federal guidelines contained in the National Contingency Plan (EPA 1990) of "acceptable" upper bound cancer risks to protect human health, including sensitive individuals, range from 1×10^{-4} to 1×10^{-6} (a 1 in 10,000 to 1 in 1,000,000 probability of developing cancer due to lifetime exposure to a carcinogen).

For air toxics, EPA has not generally defined risk levels that represent acceptable or unacceptable regulatory thresholds. However, EPA has made case-specific determinations such as the 1989 Benzene National Emission Standard for Hazardous Air Pollutants (NESHAP) that set up a two-part, risk-based decision framework. First, it set an upper limit of acceptability of 1 in 10,000 lifetime cancer risk for highly exposed individuals. Second, it set a target of protecting the greatest number of persons possible to an individual lifetime risk level no higher than approximately 1 in 1,000,000. In addition, these determinations called for considering other health and risk factors, including the uncertainty in the risk assessment, in making an overall judgment on acceptability. The EPA cautions, however, that such case-specific determinations are not designed to be definitive tools for determining acceptable risk levels because of the case-specific limitations in data and methods. In addition, the Benzene NESHAP assessment estimates average population exposures rather than the exposures experienced by the most exposed individuals. Therefore, it contains significant uncertainties (e.g., emissions levels, exposure concentrations, and toxicity) and lacks the level of refinement that would enable us to adequately assess the highest exposures found in localized "hot spots."

The EPA's National Air Toxics Assessment Program assessed exposure to the entire United States-based population based on data obtained in 1996. This assessment concluded that the entire United States population is estimated to exceed a cancer risk level of 1 in 100,000 due to background sources alone (www.epa.gov/ttn/atw/nata/risksum.html). These background sources include natural sources and uncontrollable anthropogenic sources such as international emission and global transport.

All cancer risks presented and discussed in this assessment are the incremental increased risk from exposure to constituents; they are in addition to the lifetime background risk of 1 in 3 for every American to contract cancer (DHHS 1990). Background causes of cancer include both inherited genetic and environmental (anthropogenic and natural) causes.

2.3.1.3 Synergistic Effects

Risks from individual COPCs are summed to determine the total risk. The total risk is provided as a measure of the potential synergistic effects resulting from exposure to multiple constituents. This approach is believed to be conservative (i.e., health protective), as indicated by a recent Presidential/Congressional Commission on Risk Assessment and Risk Management (1997):

> "The combined effects of exposure to constituents in a mixture are determined by how individual components of the mixture affect the biological processes involved in toxicity. Components of a mixture can affect biological processes in many ways. For example, anything that affects the absorption, distribution, metabolism, or elimination of a constituent will affect the amount of that constituent that is available to react with DNA or other cellular targets. Because interactions leading to synergism or antagonism are the result of reactions of many molecules at many cellular sites, a mathematical dose-response model of a synergistic or antagonistic response that depends on such mechanisms is most likely nonlinear at low doses. Such logic strongly suggests that any disease process that depends on such interactions is only marginally important at low exposure levels. Only at high doses of one or more mixture components - such as cigarette smoke, alcohol, and some substances in occupational exposures - is the combined effect likely to be detectably greater than the sum of the individual effects."

2.3.1.4 Acute and Chronic Non-carcinogenic Hazards

The potential for adverse health effects from short-term, acute exposures and for chronic exposures to non-carcinogens are determined by comparing estimated intake values (I) with reference doses (RfDs), both expressed in units of mg/kg/day. The RfDs are threshold levels below which no adverse effects are expected to occur. This relationship is mathematically described as follows:

$$\text{Hazard Quotient} = I/RfD$$

If intake exceeds the reference dose, the HQ will exceed 1.0, indicating a potential for adverse health effects. For simultaneous exposure to multiple constituents with similar toxic effects, a HI is calculated as the sum of constituent-specific HQs. HQs and HIs are generally reported to only one significant figure, consistent with the inherent level of accuracy of a risk assessment.

2.3.2 Acute Hazards

The quantitative assessment of acute hazards is provided in Table 2-1. All HQs and the total HI are well below 1.0, indicating no known risk from acute exposure to ground-level air concentrations at the worst case location for the 1-hour peak concentration. These results are applicable to both the general population and Facility workers.

The HI is intended as an estimate of the synergistic effects from exposure to multiple constituents. Only those constituents that result in similar constituent effects have the potential for synergy. Summing all HQs provides a simple but likely overstated assessment of the potential synergistic hazards.

Four significant figures are shown for HQs and two significant figures are shown for the HI to support a relative comparison of baseline versus cumulative hazards and to reveal major contributors to the HI. When rounded to one significant figure, acute hazard estimates for the baseline and cumulative conditions are indistinguishable.

2.3.3 Chronic Non-Carcinogenic Hazards

The evaluations of chronic exposure to non-carcinogenic COPCs are based on the 1-year annual average worst case ground-level air concentrations. Chemical-specific human health hazard quotients are presented in Attachments B-4 (baseline condition) and C-4 (cumulative condition). The estimated chronic non-carcinogenic HIs are:

	Average Exposure	**High-End Exposure**
Baseline Condition	0.05	0.1
Cumulative Condition	0.1	0.2

All HQs and the total HI are well below 1.0, indicating no known risk from chronic exposure. The assessment considers a multi-pathway exposure assessment to a future potential resident located at the Facility boundary.

The same principles discussed for the acute hazard assessment apply to the chronic hazard assessment. The HIs likely over estimate the true hazard by summing the HQs for all constituents. Also, results should only be considered accurate to one significant figure. The different HIs derived from the assessment should not be interpreted to imply different degrees of hazard. Any result below 1.0 indicates there is no hazard.

2.3.4 Blood-Lead Levels

The IEUBK model run reports, which document the input parameters and predicted blood-lead levels, are provided in Attachment D. Input values are based on predicted lead concentrations in media and food at the worst-case location. Lead concentrations in vegetables are based on the average of root and leafy vegetables. Lead concentrations in fruits are the average of predicted lead concentrations in protected and exposed produce categories. Concentrations of lead in meat are based on predicted concentrations in beef.

Applying these assumptions, the predicted blood-lead levels in children are:

- Baseline Condition geometric mean of 1.2 µg/dL with 0% exceeding 10 µg/dL
- Cumulative Condition geometric mean of 1.2 µg/dL with 0% exceeding 10 µg/dL.

The change in lead emissions for the cumulative condition did not result in significantly different blood-lead concentrations at the number of significant figures reported above. Predicted blood-lead concentrations are below the 10 µg/dL blood-lead standard established by the U.S. Center for Disease Control (CDC 1991), a level below which no special actions are recommended. The EPA (1994b) recommends that residential soil concentrations not exceed a level such that a typical child would have greater than 5 percent chance of exceeding 10 µg/dL blood.

2.3.5 Carcinogenic Risks

Exposure and risk to carcinogens is evaluated more thoroughly than for non-carcinogens. To support an understanding for how predicted risks vary under different types of exposure assumptions, risks to residents are evaluated for the following conditions:

- Risks at the Worst-case Location – evaluates risk for the most exposed type of receptor, an individual living a subsistence type of lifestyle at the location of the worst case ground-level air concentration.
- Population Distribution of Risks – evaluates the distribution of risk among individuals within a community based on Ground-level air concentrations at worst-case location and a stochastic analysis involving different exposure assumptions.
- Risks in Nearby Communities – evaluates risks to individuals living in certain established communities around the Facility.
- Risks from Locally Caught Fisk and Game – evaluates risk to individuals who hunt and fish in the area surrounding the Facility.

The evaluations of chronic exposure to carcinogenic COPCs are based on the 1-year annual average ground-level air concentrations at different locations as appropriate for each type of exposure.

2.3.5.1 Risks at the Worst-Case Location

The worst-case location is at the Facility's property boundary. Model "default"[2] exposure assumptions are used. The application of default exposure assumptions at this location is consistent with a subsistence lifestyle scenario. The future potential resident is assumed to work and live at this location and raise a large percentage of his or her food from this location. Water is assumed to come from the worst-case receptor location on the Missouri River.

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[2] The only deviation from default model assumptions is the use of the average soil concentrations over 100 years after emissions per EPA guidance (1999a), rather than 70 years as recommended by California EPA guidance (2003). Metals concentrations are most affected. For example, cadmium concentrations for the cumulative condition (Attachment C) are estimated to be 0.066 mg/kg between 0 and 70 years, and 0.094 between 0 and 100 years.

Detailed results are presented in Attachment B-4 (baseline condition) and Attachment C-4 (cumulative condition). A summary of the total cancer risks and the cancer risks for constituents with risks exceeding 1×10^{-6} are:

Worst-Case Location Risks

	Average Exposure	**High-End Exposure**
Baseline Condition		
Dioxin	1×10^{-6}	8×10^{-6}
Total*	2×10^{-6}	1×10^{-5}
Cumulative Condition		
Dioxin	1×10^{-6}	8×10^{-6}
Total*	2×10^{-6}	1×10^{-5}

*Total – the sum of risks for all COPCs.

Total risks are dominated by predicted exposure to dioxin. For the baseline condition, dioxin risk is greatest for the mother's milk pathway (3.0×10^{-7}) followed by the beef ingestion pathway (2.6×10^{-7}) and other food ingestion pathways. An important consideration in reviewing these results is that the mother's milk pathway is not a component of EPA's (1998) risk assessment methodology. Exposure via mother's milk is highly dependent upon assumptions regarding the half-life of dioxin in the mother, a factor that has not been studied extensively.

The food pathway dominating the risk estimates are a function of estimated soil concentrations. The results of this assessment should be considered in light of other soil criteria. Table 3-1 compares soil concentrations with preliminary remediation goals based on residential exposure developed by EPA Region 9 (which includes California). Criteria such as these are often used when investigating soil contamination issues as an initial step in determining whether additional investigation and/or risk assessment is necessary. All predicted soil concentrations at the location of the highest annual average ground-level air concentrations are below EPA Region 9 Preliminary Remediation Goals based on residential exposure.

2.3.5.2 Population Distribution of Risks

Individuals within a population will have different body weights, inhalation rates, ingestion rates and other factors that affect the potential for exposure to COPCs. By inputting the known range of such values for different individuals in to the risk assessment model, stochastic analysis can be used to calculate the distribution of risks for individuals within a population.

Crystal Ball is the software used to conduct the stochastic analysis for both the baseline and cumulative condition. The Crystal Ball reports documenting the model inputs and outputs for the baseline and cumulative conditions are provided in Attachments B-4 and C-4. Figure 2-3 presents the results of the stochastic risk analysis for the cumulative condition.

EPA (2004b) recommends risk management decisions be made for population risks in the 90^{th} to 99.9^{th} percentile range. In so doing, "EPA seeks to protect 'sensitive populations,' segments of the general population that are at greater risk, either because of particular sensitivity to the toxic effects of certain constituents or because they experience higher exposures than the general population, as children do."

If everyone in the community were to experience exposure based on the constituent concentrations at the worst-case location, the stochastic model as applied for the cumulative condition in this assessment indicates the following distribution of risk within the population:

Percentile	**Risk Level**
50%	5×10^{-6}
90%	6×10^{-6}
95%	7×10^{-6}
100%	1×10^{-5}

The above results indicate a strongly lognormal distribution of risk. The risk level at the 90^{th} percentile is one-half the risk level at the 100^{th} percentile (5×10^{-6} is exactly one-half of 1×10^{-5}).

Comparing the point estimate of risk with the stochastic estimate of risk can help elucidate the degree of conservatism that is built into the point estimate approach. The point estimate approach for the cumulative condition at the worst-case location estimated a risk of 1×10^{-5} (Section 2.3.5.1). This risk level is at the 100 percentile level of the stochastic analysis, indicating that high-end risk estimates provided by the point estimate approach generates risk estimates that are protective of nearly everyone in the population.

The stochastic analysis is based on inter-individual variability in behavior in the following areas: food consumption rates, inhalation rates, water ingestion rates, and mother's milk consumption rates. California EPA has not defined within their guidance distributions for incidental soil ingestion rates, dermal absorption, and exposure duration. However, distributions for other pathways have been defined by others (AIHC 1994). Studies of incidental soil ingestion indicate a strongly lognormal distribution. A few children exhibit pica tendencies (eat dirt) or exhibit other hygiene characteristics that result in higher incidental dirt ingestion, while a majority have much lower estimates of soil ingestion rates. Dermal absorption rates can be expected to vary among the population depending on the amount of clothing worn and overall skin health. Duration of residence (incorporated into the model as exposure duration) is another population distribution that is known to be lognormally distributed; although, residence duration is much longer in rural areas than in urban areas. As more model input parameters are incorporated into the stochastic analysis, the net effect mathematically is to increase the magnitude of the peak in the distribution and lengthen the tail of the distribution. In other words, the 50^{th} percentile value would not likely change but the 90^{th} percentile value would likely decrease and the 100^{th} percentile value would likely increase.

2.3.5.3 Risks in Nearby Communities

Focusing on worst-case location provides an upper-bound evaluation of risk to residents. Risks will reduce as ground-level air concentrations reduce with distance from the Facility. This section of the report quantifies the risks at different receptor points located near established communities.

Under the exposure assumptions used in the default model, COPC exposure via food ingestion results in the highest risk levels. Risks to residents in various communities will not change if it is assumed that foods are obtained from the location of maximum impact. Therefore, the evaluation of risks in nearby communities begins by first evaluating non-food related exposure pathways, based on ground-level air concentrations at receptor points near each community. Default model assumptions for non-food related pathways are unchanged. Using this approach, the cumulative condition risks are:

Cumulative Condition Risks for Non-Ingestion* Pathways in Various Communities

	Average Exposure	High-End Exposure
Worst-Case Location	7×10^{-7}	3×10^{-6}
Three Forks School	2×10^{-8}	5×10^{-8}
Manhattan	4×10^{-9}	1×10^{-8}
Belgrade Airport	2×10^{-9}	9×10^{-9}

*Includes inhalation, dermal absorption and soil ingestion pathways based on predicted soil concentrations for each community.

Risks are substantially different across communities when considering only non-food pathways. This scenario is applicable to community residents without gardens who obtain food through supermarkets. Under these assumptions, risks are 100 to 1,000 times smaller in the communities than for the future potential worst-case receptor (Section 2.3.5.1). Among the communities evaluated, risks are highest for residents in or near Three Forks.

The Three Forks receptor location is used to evaluate exposure via all pathways, including the food pathways. The most likely existing and future potential scenario arguably involves cattle grazing and/or grain production (protected produce) in the general area surrounding the Facility and exposure via other food pathways (e.g., garden produce, other meats, inhalation, incidental soil ingestion, and dermal exposure) based on ground-level air concentrations at the respective communities. The methodology used to evaluate ground-level air concentrations to which cattle and grain are exposed is identical to the procedure used to evaluate ecological exposure (Section 3.1.1.2). The methodology is based on the average concentration in a 36-mile region surrounding the Facility.

Estimated risks for the Three Forks School receptor under the cumulative condition are:

Most Likely Scenario Cumulative Condition Risks for Three Forks Residents

	Average Exposure	**High-End Exposure**
Beef*	2×10^{-8}	1×10^{-7}
Protected Produce*	7×10^{-10}	6×10^{-9}
Mother's Milk*	2×10^{-8}	2×10^{-7}
Other Foods**	1×10^{-8}	9×10^{-8}
Inhalation**	7×10^{-9}	3×10^{-8}
Dermal**	3×10^{-10}	1×10^{-8}
Soil Ingestion**	8×10^{-9}	2×10^{-8}
Water Ingestion**	7×10^{-11}	4×10^{-10}
Total	$\mathbf{7 \times 10^{-8}}$	$\mathbf{5 \times 10^{-7}}$

*Based on average Ground-level concentrations over a region surrounding the Facility. Grain (used for bread) is considered to be a Protected Produce. Mother's Milk calculations are only performed for dioxin and PCBs, and the results are most controlled by beef and poultry ingestion; therefore, exposure assumptions used to estimate beef exposure are used for Mother's Milk.
**Based on ground-level air concentrations at the Three Forks School.

Aggregate risk from exposure to all COPCs for this scenario is below 1×10^{-5}. The highest risk for any one constituent is from exposure to dioxin based on beef ingestion and mother's milk ingestion, which equals 3×10^{-7} for the high-end exposure scenario and 4 x 10^{-8} for the average exposure scenario. Risk estimates for exposure to dioxin, and total risks, would increase if a smaller area of concern were used to evaluate beef ingestion. The highest predicted risk for a smaller area would not exceed the risk predicted for the worst-case receptors (Section 2.3.5.1). Risk estimates for exposure to dioxin, and total risks, would decrease if a larger area of concern were used to evaluate beef ingestion.

2.3.5.4 Risks from Locally Caught Fish and Game

This section of the assessment evaluates risks associated with the consumption of fish and game obtained from the area around the Facility. In proportion to the amount of fish and game that is ingested, the risks associated with fish and game ingestion will replace the risks estimated for beef ingestion in other scenarios evaluated by this assessment.

River Fish. COPC concentrations in fish in rivers are estimated based on predicted COPC concentrations at the most downstream and worst-case receptor location on the Missouri River. Risks from fish consumption are much lower than risks for other pathways (cumulative condition risk is 2×10^{-8} for the high-end exposure scenario and 1×10^{-9} for the average scenario).

Lake/Pond Fish. Risks from fish consumption in lakes and ponds are based on a pond in the Three Forks area with size and water flow assumptions as presented in Section 2.1.2.3. The estimated risk for the high-end fish consumption rate is 6×10^{-6}, and the estimated risk for the average fish consumption rate is 5×10^{-7}. About 60 percent of the risk is due to dioxin exposure (3×10^{-6}) and about 40 percent of the risk is due to PCB exposure (2×10^{-6}), based on the high-end exposure scenario.

Locally Hunted Game. Risks from the consumption of game will vary depending on the total amount of meat an individual typically consumes and the percentage of the game meat that is derived from locally hunted deer that graze in areas surrounding the Facility. Accounting for these variables, the predicted risks associated with the cumulative condition are as follows:

Cumulative Condition Risk from Consumption of Local Deer

	Average Exposure	High-End Exposure
15% meat from area*	5×10^{-9}	4×10^{-8}
100% meat from area	4×10^{-8}	3×10^{-7}

*Model default value for beef ingestion.

Essentially all of the risk is predicted to occur as a result of exposure to dioxin.

2.4 UNCERTAINTY AND VARIABILITY

In the context of this risk assessment, uncertainty is defined as a lack of precise knowledge of the true risks, while variability is defined as the inherent heterogeneity in risks across space, time, or among individuals. While uncertainty can be reduced with increased information, variability cannot.

An assessment of variability is integrated into the characterization of carcinogenic risks (Section 2.3.5). The variability assessment considers the distribution of risk in a population using stochastic analysis, and it evaluates risks spatially for different communities and lifestyles. A range of exposure assumptions is considered. The intent is to show how different exposure assumptions affect risk estimates, and to present a range of exposure assumptions from which risk management decisions can be made.

Uncertainty is inherent in every model input factor used in this and other risk assessments to varying degrees. The usefulness of risk assessment in light of this uncertainty is debated. By adhering to an agency-approved methodology while accounting for site-specific factors where possible, the results of this assessment may be compared with risks estimated using the same methodology at other sites. In this manner, this risk assessment is intended to provide a consistent basis for understanding risks and making decisions.

Some elements of uncertainty cannot be addressed on a project-specific basis. Most important in this regard concerns the cancer slope factors. As stated in Section 2.3, there are many unknowns regarding the biological processes that control carcinogenic risk at low concentrations. The EPA policy in this regard has been to conservatively estimate cancer slope factors for use in risk assessments based on what is scientifically known, allowing a margin of safety for the unknown. As dioxin is an important COPC in this assessment, it should be recognized that EPA is conducting a reassessment of dioxin toxicity. The results of this reassessment are not expected until 2006.

There are also many areas of uncertainty regarding this exposure assessment. Emission estimates are largely based on data from other facilities (Lorenzen 2004). The observed stack emission rates at other facilities for many parameters may range over three orders of magnitude. By selecting the upper bound estimate of the emission rate, this assessment endeavors to provide a conservative estimate of emission rates for Holcim. At a 95 percent level of confidence, by definition we would expect true emission rates to be lower than the predicted rates for 19 out of every 20 COPCs. This statistical approach likely provides a conservative estimate of the total risk. The emission estimates were compared to stack test results for select COPCs and found to be conservative (Lorenzen 2004). However, other statistical considerations are involved when trying to observe the change in risk for before and after use of Whole Tires. The data set used to estimate emissions shows considerable variability in COPC emissions between facilities. When variability of COPC emission between facilities is significantly greater than the variability in emissions associated with Whole Tires, the ability to observe relatively small changes in emission rates for before and after use of Whole Tires are obscured.

Additional uncertainty is inherent in estimating the emission rates for certain COPCs associated with glass and slag use at Holcim, since it is unknown if these materials were used at the other facilities. Emission rate estimates were increased for the relevant COPCs to account for this uncertainty.

Chemical fate and transport modeling is also subject to many areas of uncertainty. The models used to predict COPC concentrations in environmental media and the resulting exposure levels are largely theoretical and have not been validated. Any efforts to do so would be difficult because of the need to account for the many site-specific factors. Site-specific soil concentrations depend on such factors as grains size, percent organic matter, temperature, rainfall, wind conditions, and other factors. Biouptake depends on nutritional status, quality of pasture (as relates to soil ingestion for grazing animals), the types of food consumed, various physiological characteristics such as percent body fat, and other factors. For example, the default soil bulk density value is 1,333 kg/m^3, which is similar to bulk density values for top soils and other low-density materials. Dry sand and gravel has a bulk soil density in the range of 1,930 kg/m^3, and some other types of soil have even higher soil bulk densities. Substituting a bulk density of 1,930 kg/m^3 into the model would reduce soil concentrations and risks by about 30 percent. To account for these kinds of uncertainty, the default model uses a combination of average and upper bound estimates of model input factors such that the resulting exposure and risk estimates will likely predict a reasonable upper limit estimate of exposure and risk, providing a reasonable degree of protection against the unknown.

Some of the uncertainty in this risk assessment could be reduced on this project through site investigations of actual ground-level air concentrations, soil concentrations, water and sediment concentrations, and/or concentrations in plants and animals. Any such site investigation would be complicated significantly by the low levels of media concentrations predicted by the exposure assessment, as shown in Attachments B (baseline condition) and C (cumulative condition). In soils for example, estimates for the baseline condition (Attachment B-1) indicate that after 70 years of accumulation soil concentrations for all constituents, except zinc, would be below levels that can be routinely detected. Zinc accumulation in soil is estimated to be measurable in less than 10 years of accumulation for both the baseline and cumulative conditions, and exceed median background levels for the conterminous United States within 20 years of accumulation. PAH concentrations in soil are estimated to be nearly equal to the detection limit in the baseline condition within the first 10 years of accumulation and then achieve equilibrium with natural decay processes. Because of measurement precision and accuracy limitations at this level, it is unlikely that a soil survey could identify PAH accumulations in soil. A comparison of the predicted soil concentrations with routine detection limits and background concentrations in the United States is provided in Table 3-1.

2.5 SUMMARY AND CONCLUSIONS

This assessment evaluated exposure to HAPs emitted from the stack and other sources of CKD managed at the Holcim Cement Plant in Trident, Montana. The assessment considered emissions without the use of Whole Tires (baseline condition) and with the use of Whole Tires (cumulative condition). Principle findings are:

- Metals, and to a lesser degree organic constituents, are predicted to accumulate in soils as a result of continued long-term Facility emissions. Accumulated concentrations after 70 years of emissions are expected to be below routinely detectable levels for nearly all COPCs. Zinc is expected to accumulate to detectable levels under both the baseline and cumulative conditions within 10 years. Under the baseline scenario only, PAH levels are expected to approach the detection limit within 10 years, but reach a dynamic equilibrium and not increase in concentration with future emissions.

- Acute and chronic exposure and hazards are below levels of concern. The HI for acute exposure under high-end exposure assumptions at the worst-case location is 0.4 for both the baseline and cumulative conditions. The HI for chronic exposure under high-end exposure assumptions at the worst-case location is 0.2 for the baseline condition and 0.3 for the cumulative condition.

- Lead exposures resulting from Facility emissions under baseline and cumulative conditions are below background levels of exposure used by the EPA to evaluate lead exposure nationally. Predicted blood-lead levels at the worst-case receptor location are far below the 10 µg/dL blood-lead level of concern.

- The total risk for the cumulative condition is essentially identical to the estimated risks for the baseline condition when appropriately expressed using one significant figure (e.g., 1×10^{-5} for high-end exposure at the worst-case location).

- Cancer risk varies for the different scenarios evaluated. The highest risk is for a subsistence lifestyle scenario at the Facility property boundary (cumulative condition risk of 1×10^{-5} for the high-end exposure condition and 2×10^{-6} for the average exposure condition). The lowest risks are for residents in Three Forks, Manhattan, and Belgrade who obtain their food from supermarkets (cumulative condition risk ranging from 2×10^{-9} for the average exposure condition at the lowest exposure location to 5×10^{-8} for the high-end exposure condition at the highest exposure location). Risks for the most likely scenario, residents in Three Forks who obtain some food products from the general area around the Facility, either domestic or wild game, have higher estimated risks (cumulative condition risk of 7×10^{-8} for the average exposure condition and 4×10^{-7} for the high-end exposure condition).

- Total risk is dominated by consumption of predicted levels of dioxin in beef and mother's milk, and to a lesser extent by consumption of poultry and dairy products.

- Consumption of fish from local rivers produces much lower risk estimates. Risk from river fish consumption for the cumulative condition high-end exposure estimate, which assumes 74 pounds per year of fish ingestion, is 2×10^{-8}. Risk from exposure to fish in lakes in ponds is strongly affected by assumptions regarding the location and configuration of the pond. This assessment evaluated a pond in Three Forks, which resulted in a cumulative condition high-end risk estimate of 6×10^{-6} and average risk estimate of 5×10^{-7}. About 60 percent of this risk is due to predicted dioxin exposure and about 40 percent of the risk is due to predicted PCB exposure.

- Risks from consumption of locally hunted big game are estimated to range from 5×10^{-9} for average meat consumption rates assuming 15 percent of meat ingestion is derived from the site to 3×10^{-7} for the high-end meat consumption rates and assuming 100 percent of the meat is obtained from areas nearby the Facility. Essentially all the risk is attributed to predicted dioxin exposure.

- Stochastic analysis indicates that the risks to residents are lognormally distributed. Risks for most residents are approximated by the median exposure condition, with relatively few residents described by the high-end risk estimates. Stochastic analysis of the worst-case exposure scenario (i.e. the subsistence lifestyle at the Facility boundary) for the cumulative condition indicates a median risk of 5×10^{-6}. The high-end risk estimate derived using the point-estimate approach results in risk estimates that are near the 100th percentile of the distribution (cumulative condition risk of 1×10^{-5}), while risks at the 90th percentile level are about half as large (cumulative condition risk of 6×10^{-6}).

In consideration of the above findings, a vast majority of the people in the area are predicted to experience risks that are at levels at or below the range that is generally considered to be acceptable (1 in 10,000 to 1 in 1,000,000). These risks are the incrementally increased risk of cancer as a result of lifetime exposure to COPCs from the site. The background rate of cancer from all sources (natural and anthropogenic) is 1 in 3. Certain types of land use and lifestyles in close proximity to the Facility will result in larger incrementally increased cancer risk than would be experienced by the general population; for example subsistence living or concentrated agricultural operations such as feed lots, green houses, fish farms, or organic farms.[3]

[3] Standards regarding constituent quality of organic foods are restricted to pesticide and herbicide residues. The inclusion of organic farms in this category assumes that consumers of organic produce would not want food products exposed to anthropogenic constituents at levels above background levels or levels that can be detected using standard analytical methods.

3. ECOLOGICAL RISK ASSESSMENT

The organization of the ecological risk assessment is similar to the human health risk assessment, with the quantitative assessment consisting of three primary parts. Section 3.1, Exposure Assessment, evaluates the fate and transport of constituents in the environment and establishes the routes by which organisms may be exposed to the COPCs. For terrestrial ecological receptors, calculations are made regarding the exposed dose, which is expressed as milligrams of constituent ingested per kilogram body weight per day (mg/kg/day). Section 3.2, Toxicity Assessment, identifies quantitative measures of toxicity for each COPC that are comparable to the dose. Section 3.3, Risk Characterization, calculates risk by comparing exposure under the various exposure scenarios to toxicity. The remaining two sections provide further evaluation of the results. Section 3.4, Uncertainty and Variability, addresses more qualitative aspects of the assessment. Section 3.5, Summary and Conclusions, integrates both the quantitative and qualitative aspects of the risk assessment into a concise summary in support of informed risk management decision-making.

3.1 EXPOSURE ASSESSMENT

The fate and transport of COPCs emitted from the Facility is identical to the process described for the human health exposure assessment (Section 2.1 and Figure 2-1). There are two primary differences when considering ecological risk: food web considerations and area of exposure. The area of exposure affects how media concentrations (e.g., air, soil, and food) are determined. Additionally, ecological species to be used in the quantitative assessment must be selected. Since it is not feasible to quantitatively evaluate all species that may exist in the area, species must be selected to represent the various types of species existing in the area which are of potential concern.

3.1.1 Terrestrial Exposure Assessment

Arid grassland and dry-land farming is the dominant type of ecosystem surrounding the Facility. Habitat characterized by cottonwood trees and various shrubs predominate along the major area rivers. Wetlands occur in the Three Forks Area.

3.1.1.1 Species Selection and Food Web Considerations

Figure 3-1 presents a food web for the terrestrial area around the Facility. The various guilds (e.g., carnivorous mammals) and food web relationships are based on the shortgrass prairie model developed by EPA (1999a) (Figure 3-1). The example species are based on a general understanding of species common to Montana and the area.

The food web provides a summary of the various types of species that could be evaluated. The selection of species and food web pathways for quantitative evaluation is based on the following:

- Selecting species representative of the range of species that potentially exist at the site.

- Selecting species for which there is sufficient exposure and toxicity information to support quantitative analysis. Note that reptiles were not selected for quantitative assessment because there is limited data to support an evaluation of risk to these organisms. Also note that no example species are listed for terrestrial plants. This reflects the fact that species-specific toxicity information is not available for native plants in the area of this project. Most plant toxicity information is obtained from studies conducted on agricultural crops.

- Consideration for rare species, species of special economic value, or species of interest to the general public.

    - Section 3 of the EIS (DEQ 2005) identifies rare species that may exist in a 50 km radius of the Holcim Facility. Those species potentially existing in the area and listed as threatened by the U.S. Fish and Wildlife service are the Bald Eagle, Lynx and Ute ladies' tresses (a plant). The Bald Eagle and Lynx are designated as "Threatened" under the Endangered Species Act. Many other species of special concern for one or more reasons are identified in the EIS. These can be generally summarized to include: seven species of carnivorous, insectivorous or piscivorous birds; six species of aquatic insects; three mammal species (Fringed myotis – a type of bat, Lynx and Townsend's big-eared bat), thirteen plant species, and three fish species (Yellowstone cutthroat trout, Westslope cutthroat trout and artic grayling). The terrestrial species of special concern are represented by a surrogate species of the same trophic level as shown in Figure 3-1, as per EPA guidance (EPA, 1999a). Aquatic species are not selected for quantitative assessment, for reasons explained in Section 3.1.2.

    - Public scoping (DEQ 2004) identified several species of special economic value and interest to the general public, including fish, plants, deer, and antelope. Fish and plants were previously evaluated by Bison and Kleinfelder (2004c) and are also selected for evaluation in this assessment. The deer was selected for evaluation in this assessment in addition to rabbits (which had been previously evaluated, Bison and Kleinfelder 2004c) to represent larger herbivorous mammals. This selection was made because of public interest in maintaining the health of game species. Also, the deer is potentially more susceptible to adverse effects from exposure to COPCs because it is much larger than the rabbit (see toxicity factor discussion, Section 3.3.2). The assessment of potential risks to deer is considered representative of risks to antelope.

- Consideration for organisms in higher trophic levels to account for bioconcentration and bioaccumulation of COPCs. Bioconcentration refers to the ratio of concentrations in animal food items to concentrations in environmental media. Bioaccumulation refers to the magnification of constituent concentrations in organisms within the food chain. Each is considered separately.

    - To minimize unnecessary complexity in the evaluation of bioconcentration, only a subset of the food pathway models available from EPA guidance are included in this assessment. This approach is based on the fact that an organism can only eat a fixed quantity of food per day. If, as assumed in this assessment, all of the fox's diet is proportioned to the rabbit, then it would not be correct to also consider exposure through consumption of robins. This exposure assessment uses bioconcentration factors provided in EPA guidance (1999a) to estimate body burdens of species (e.g., ingested prey hazard index assessment for the red-tailed hawk, Attachments E-4 and F-4).

- Bioaccumulation is not quantitatively accounted for in this assessment (e.g., herbivorous mammal to omnivorous mammal to carnivorous mammal and/or carnivorous birds) to reduce further assessment complexity. Incorporation of this pathway would result in higher quantitative estimates of risk to Trophic Level 4 species. However, a cursory examination of this pathway (Section 3.3.2.3) indicated that risks would not exceed levels of concern. Therefore, bioaccumulation is addressed qualitatively.

3.1.1.2 Air Concentrations

Risks are calculated based on ground-level air concentrations at the worst-case receptor location and for a broader region around the Holcim Facility. For the default model provided in Attachments E and F, media concentrations are determined based on the average ground-level air concentrations over approximately a 36-square mile region surrounding the Holcim Facility. An average dispersion coefficient value of 0.01945 was derived by averaging dispersion coefficient values for the receptor points shown on Figure 3-2. The following considerations went into selecting a 36-square mile region:

- Ecological risk assessment is principally concerned with overall ecosystem health and vitality. Potential ecological risk to a small group of organisms in a small area represented by the maximum exposure point may not be a useful measure of risk at the ecosystem level. Use of the maximum exposure point to determine media concentrations is a valid simplification only if risks are below levels of potential concern.

- Terrestrial animals will move freely about the area surrounding the Facility. The territory size will vary by species and based on habitat quality. The red fox home territory ranges from 57 to 170 hectares, while the robin's home territory is less than 1 hectare. One hundred hectares is equivalent to 0.386 square miles.

- Using a contour map of the dispersion coefficients, an area of uniform shape was defined that surrounded the Facility and included the areas of highest potential ground-level air concentrations.

The selection of the area over which exposure should be averaged is subjective. The intent is to show how risks change between the worst-case location and the broader area surrounding the Facility more generally. Soil and forage concentration calculations and results are provided in Attachment E-1 (baseline condition) and Attachment F-1 (cumulative condition).

3.1.1.3 Soil and Forage Concentrations

Soil and animal forage concentrations were calculated using the same model as described for the human health risk assessment. The soil calculations are provided in Attachment E-1 (baseline condition) and F-1 (cumulative condition), and forage concentration calculations are provided in Attachment E-3 (baseline condition) and F-3 (cumulative condition).

Concentrations are the average predicted concentrations over 100 years of Facility operation. A soil depth of 0.15 meters is used for calculating soil concentrations in the default models used in this ecological risk assessment; a value defined by California EPA guidance (2003) for agricultural exposure pathways in the human health risk assessment. Conversely, U.S. EPA guidance (1999a) suggests 0.01-meter soil depth be used for untilled soil and 0.2-meter depth be used for tilled soil. EPA also assumes a different soil bulk density of 1,500 kg/m^3. The implications of these different assumptions are quantitatively evaluated in Section 3.3.2.2.

3.1.1.4 Water Concentrations

Predicted water concentrations are significantly higher in lakes than in rivers. The concentration in lakes is dependent upon many assumptions about lake size, depth, location, and number of volume changes per year. Other factors that may affect predicted exposure concentrations include evaporation and accumulation of COPCs in sediments. This assessment conservatively assumes that wildlife get all their drinking water from lakes. Lake water concentrations are based on deposition rates for the Jefferson 2 river receptor and lake dimension assumptions described in Section 2.1.2.3.

3.1.2 Aquatic Exposure Assessment

Upstream of the Facility, the Madison, Jefferson, and Gallatin Rivers come together to form the headwaters to the Missouri River. The Three Forks Area, where the rivers converge, has a myriad of small lakes, ponds, and wetlands. The rivers, lakes, and ponds in the area are best described as cold water fisheries.

Consistent with EPA (1999a) guidance, risks to fish and aquatic invertebrates in the area rivers and lakes are evaluated by comparison of COPC concentrations in water and sediments to their respective media standards.

A food web and species-specific risk assessment for higher trophic level organisms in the aquatic environment is not included with this risk assessment. Such a food web would consider fish-eating birds such as an osprey, wading bird such as a sandpiper, and aquatic mammals such as a beaver, among other possible types of species. Water quality standards have been applied extensively in the regulation of ambient water quality. The toxicological basis underlying the development of the standards has a strong orientation toward aquatic life in cold water systems; although there is limited consideration for higher trophic level species. To address this bias, risks to higher trophic level organisms are addressed qualitatively in the Summary and Conclusions (Section 3.5).

3.2 TOXICITY ASSESSMENT

Ecological toxicity assessment involves a considerable amount of variability. There are multiple sources of toxicity values, with the source of the toxicity value changing depending on the media of concern and species of concern. This toxicity assessment is approached in two ways to provide a more diverse perspective on potential ecological toxicity and risk. A screening level-type assessment is provided that involves a comparison of predicted media concentrations to media standards. Also, toxicity reference dose values are selected for use in a more rigorous site-specific risk assessment.

3.2.1 Media Criteria

Tables 3-1 through 3-3 present predicted media concentrations and compares them to routine detection limits, average background concentrations, and a selection of screening level criteria. Some screening criteria are specific to certain types of species, such as plants or invertebrates. Other criteria apply to terrestrial systems in general, considering all trophic levels. The approach used to develop the more general screening level values is to base the criteria on the exposure pathway (e.g., shrew) that provides the lowest soil concentration. Similarly, criteria for plants are based on those species, among those tested, that are more sensitive to the constituent of concern. Using this approach, the criteria are thought to be protective of plants generally. The bases (i.e., type of organism) used to develop the criteria are listed in the tables where such information is provided with the published value.

Screening level criteria are not regulatory standards that must be complied with, nor are they a definitive measure of ecological harm. They are generally used as a simple and conservative method for identifying a potential for harm and the need for more detailed evaluation.

A discussion of the findings provided by Tables 3-1 through 3-3 is reserved for Section 3.3, Risk Characterization.

3.2.2 Toxicity Factors

The toxicity factors selected for use in the ecological risk assessment are derived from Bison and Kleinfelder (2004c), with some exceptions as described in part below. References for the toxicity factors are provided in Attachments E-4 and F-4.

The evaluation of risk to plants, invertebrates, and aquatic life involves a direct comparison to media standards (EPA 1999a). This approach is identical to the media standards approach presented in Section 3.2.1 except that only a single toxicity factor is used in the hazard assessment. It is often, but not always, one of the values provided in the media comparison tables (Tables 3-1 through 3-3).

The evaluations of risk to birds and terrestrial animals are based on calculations of dose from exposure to COPCs in air, water, soil, and diet. Toxicity reference values based on dose (i.e., milligrams taken into the body per kilogram body weight) are used to support this kind of assessment. Toxicity factors are generally derived from toxicity studies conducted in a laboratory. Toxicity information is rarely available for the species of interest. Moreover, the toxicity data supporting the standard may include: no observed adverse effect levels (NOAELs), lowest observed adverse effect levels (LOAELs), median lethality levels, or other types of data. EPA guidance (1999a) establishes protocols for the selection of preferred toxicity data and the selection of uncertainty factors. Uncertainty factors are used for species extrapolations and when extrapolating no observed effect levels from other kinds of data. The uncertainty factors used in this assessment are shown in Attachments E-4 and F-4.

A protocol has been developed for adjusting toxicity reference values when extrapolating between species that is based on body weight (Sample et al. 1996). Using this approach, toxicity factors are lowered (i.e. made more stringent) for species with larger body weights. According to Sample et al., "Smaller animals have higher metabolic rates and are more resistant to toxic constituents because of more rapid rates of detoxification." This assessment used this approach to adjust toxicity factors.

EPA guidance (1999a) does not include exposure or toxicity assessment via inhalation because adequate data to support inhalation toxicity assessment for wildlife species have not been developed. This assessment does assess the inhalation pathway using toxicity factors developed for exposure from ingestion pathways. This approach is a carryover from the approach used by Bison and Kleinfelder (2004c). In all cases, exposure received from inhalation is much lower than exposure estimated for other pathways. The inclusion or exclusion of this pathway does not significantly change the HI results for this assessment.

3.3 RISK CHARACTERIZATION

This section of the report presents the quantitative results of the ecological risk assessment. Section 3.3.1 provides a screening level evaluation of risk based on a comparison of predicted COPC concentrations in environmental media with generic media-based criteria. The site-specific ecological risk assessment results are presented in Section 3.3.2.

3.3.1 Screening Level Comparison to Media Criteria

Soils. Average soil concentrations for the broader area surrounding the Facility do not exceed any comparison criteria provided in Table 3-1. For the location of highest predicted soil concentrations, manganese exceeds the detection limit, but not screening level health criteria. Again for the location of highest predicted soil concentrations, soil concentrations of inorganic mercury, selenium, and naphthalene for both the baseline and cumulative conditions are below detection limits and exceed some but not all of the screening level health criteria. Predicted concentrations of zinc at the worst case location greatly exceed detection limits and several criteria.

Surface Waters and Sediments. As shown in Table 3-2 (surface water) and Table 3-3 (sediments), estimated surface water and sediment concentrations for rivers and lakes are substantially below all comparison values.

3.3.2 Hazard Indexes

The potential for adverse ecological health effects from exposure to COPCs are determined by comparing estimated intake values (I) with reference doses (RfDs), both expressed in terms of mg/kg/day. The RfDs are threshold concentrations below which no adverse effects are expected to occur. This relationship is mathematically described as follows:

Hazard Quotient = I/RfD

If intake exceeds the reference dose, the HQ will exceed 1.0, indicating a potential for adverse health effects. For simultaneous exposure to multiple constituents with similar toxic effects, a HI is calculated as the sum of constituent-specific HQs. HQs and HIs are generally reported to only one significant figure, consistent with the inherent level of accuracy of a risk assessment.

3.3.2.1 Hazard Indexes Using California EPA Assumptions

Calculations supporting the derivation of the HIs are provided in Attachments E-4 (baseline condition) and F-4 (cumulative condition). A summary of the findings are:

Ecological Hazard Indexes

	Worst-Case Receptor		**Area Around Facility**	
	Baseline Condition	**Cumulative Condition**	**Baseline Condition**	**Cumulative Condition**
Terrestrial Plants	0.4	0.3	0.03	0.02
Aquatic Life – Rivers	NA	NA	0.0007	0.0007
Aquatic Life – Lakes	NA	NA	0.3	0.3
Aquatic Invertebrates – Rivers	NA	NA	0.0006	0.0003
Aquatic Invertebrates – Lakes	NA	NA	0.2	0.1
Terrestrial Invertebrates	0.4	0.3	0.03	0.02
Small Herbivores (rabbit)	0.08	0.06	0.04	0.04
Large Herbivores (deer)	0.03	0.03	0.01	0.01
Avian Carnivores (hawk)	7	7	0.4	0.4
Mammalian Carnivores (fox)	0.01	0.007	0.0008	0.0006
Avian Omnivores and Herbivores (robin)	1	1	0.08	0.07

NA – Not applicable. The Worst Case Receptor does not apply to a location containing a water body.

Results are rounded to one significant figure to preclude overstating the inherent accuracy of the assessment. Cumulative condition hazards are slightly below baseline condition hazards for most types of organisms. Most HIs are below 1.0, indicating no ecological hazard. Applying California EPA assumptions, the above results indicate that at the worst-case receptor there is a potential for impacts to small birds with limited home territory range. Potential hazard to carnivorous birds at the worst-case location is also indicated, with the risk entirely due to dioxin exposure via soil ingestion. Further discussion of these hazards follows the presentation of hazards using select EPA assumptions.

3.3.2.2 Using Select EPA Exposure Assumptions

The EPA (1999a) recommends that soil concentrations be based on deposition and mixing within the top 0.01 meter of soil, compared with 0.15 meters used by the California EPA for evaluating agricultural exposure. The EPA also assumes a different soil bulk density value (1,500 kg/m^3) than the California EPA (1,333 kg/m^3). Applying these assumptions produces much higher HIs, as shown for the area around the Facility below.

Terrestrial Ecological Hazard Indexes for the Area Around the Facility Using Select EPA Assumptions*

	Baseline Condition	Cumulative Condition
Terrestrial Plants	0.4	0.2
Terrestrial Invertebrates	0.4	0.2
Small Herbivores (rabbit)	0.08	0.05
Large Herbivores (deer)	0.3	0.2
Avian Carnivores (hawk)	6	6
Mammalian Carnivores (fox)	0.009	0.006
Avian Omnivores and Herbivores (robin)	1	0.8

*Soil depth changed from 0.15m to 0.01m and soil bulk density changes from 1,333 kg/m^3 to 1,500 kg/m^3.

Under these assumptions, hazards to all terrestrial species except carnivorous birds and omnivorous and herbivorous birds are below levels of potential concern. A potential impact to omnivorous and herbivorous birds are implicated within the area surrounding the Facility. Exposure to various metals via earthworm ingestion contributes most to the HI. Note that no single HQ (Attachments E and F) exceeds 1. Adding the HQs for all constituents to obtain a HI is only appropriate for constituents with similar types of toxic effects. An evaluation of the different ecological toxicity endpoints is not provided with this assessment. The HQ and HI for the hawk is entirely a function of exposure to dioxin via soil ingestion (if dioxin exposure via soil ingestion is set to 0, the HQ goes to 0.07 for the Baseline condition).

3.3.2.3 Bioaccumulation Considerations

Bioaccumulation of COPCs in carnivores is not incorporated into the HIs. EPA guidance (1999a) accounts for bioaccumulation by using food chain multipliers. The food chain multipliers are based on the octanol/water partition coefficient (which describes the constituent’s tendency to partition into fat) of a constituent and the trophic level of the organism. The highest food chain multiplier for any constituent and trophic level is 27. The lowest is less than 1. Since linear algebraic equations are used to calculate dose and toxicity, use of a food chain multiplier would result in no more than a 27-fold increase in the HI. This food chain multiplier only applies to the dose and hazard calculations for the food ingestion pathway, where trophic level 3 organisms (Figure 3-1) may be ingested. For carnivores, soil ingestion pathways provide the greatest estimated exposure. A review of the hazard quotients for the prey ingestion pathways indicates that conclusions regarding carnivore hazards would remain unchanged if quantitative estimates of food chain biomagnification were performed.

3.3.2.4 Aquatic Life Considerations

Hazards to aquatic life and aquatic invertebrates in rivers are far below levels of potential concern. For ponds, lakes, and reservoirs, hazards to aquatic life and aquatic invertebrates are strongly controlled by certain assumptions such as: the location of the pond, the ratio of surface area to water depth, and the number of volume changes per year. The highest HQs are for PAHs and methyl mercury.

The hazards associated with ponds may extend beyond fish and invertebrates to other species such as wading birds, ospreys, and beavers. These higher trophic level impacts are not assessed using a risk assessment methodology. Risks to higher trophic level organisms would be strongly dependent upon assumptions regarding the percent of food consumed in ponds versus rivers.

Numeric water quality standards have been established by the DEQ in accordance with the Montana Water Quality Act (75-5-101 et seq., 1967). The numeric standards are intended to protect the present and future most beneficial uses of state waters. As part of a broad regulatory program for managing water quality in Montana, these numeric standards are used to protect aquatic life generally, including higher trophic level organisms. As shown in Table 3-2, water concentrations predicted by the assumptions of this assessment are below Montana's numeric standards and other comparison criteria[4]. Similarly, sediment concentrations predicted by this assessment are below select comparison criteria. Numeric regulatory standards for constituents in sediments have not been established.

3.4 UNCERTAINTY AND VARIABILITY

As in the human health risk assessment, uncertainty is defined as a lack of precise knowledge regarding the true risk, while variability is defined as the inherent heterogeneity in risk across space, time, or among individuals. While uncertainty can be reduced with increased information, variability cannot.

Ecological risk assessment inherently involves greater uncertainty and variability than human health risk assessment. There are multitudes of different organisms that interact within a complex food web. When compared to human health assessments, there are generally fewer supporting studies and greater uncertainty regarding certain exposure

[4] For purposes of this report, the term standard refers to a legal requirement or numeric value, while the term criteria generally refers to risk-based values published in agency guidance.

factors such as soil ingestion rates for various wildlife species. Moreover, efforts to relate numeric risk estimates to observable ecological impacts are confounded by a host of natural factors affecting ecological health, such as climate conditions and food abundance.

The use of both media standards and risk assessment methods is intended to provide a more thorough examination of potential risks across species. Also, media standards and toxicity factors are established based on no observed effect levels, generally involving toxicity to the most sensitive species for which there is data. Margins of safety are used where there is limited information. Using these procedures, the toxicity criteria are intended to be protective of most species, most of the time.

Reductions in ecological risk assessment uncertainty may not be possible through field investigations of constituent concentrations. Except for zinc in soil, all constituent concentrations predicted by this assessment are below routine detection limits (Tables 3-1 through 3-3).

3.5 SUMMARY AND CONCLUSIONS

Potential hazards may exist for small herbivorous and omnivorous birds such as robins and meadowlarks that have home territories of limited range in areas of highest ground-level air concentrations. Metals are the primary contributors to the elevated HI, although no single metal has an HQ greater than 1.0.

Avian carnivores may also be at risk from exposure to dioxin in soil. The HIs may be above or below 1.0 depending on the assumptions used to determine soil mixing depth and soil bulk density. Dioxin emissions are set equal to the PC-MACT limit (0.2 lb/hr), while the average test data for the Facility indicates dioxin emission rates that are nearly 100 times lower (0.00207 lbs/hr) (Lorenzen 2004, Appendix C). If the actual emission rates were used in the model, the HI for avian carnivores would be much less than 1.0.

Potential hazards in river systems are very low because of the large dilution associated with flowing water. Potential hazards in lakes, ponds, and reservoirs will vary greatly depending upon the location of the water body, the size and depth of the water body, and the number of times per year the water volume in the water body changes. The assessment evaluated water concentrations in a pond that may be considered typical of water bodies in the Three Forks Area. The risk assessment focuses on risk to aquatic life, namely fish. Comparisons of predicted water quality to water quality standards are provided to support an assessment of aquatic ecosystems generally, including higher trophic level organisms. Predicted surface water concentrations for all constituents are below Montana Aquatic Life Standards (Table 3-2). Therefore, hazards to aquatic life in most water bodies in the Three Forks Area are expected to be below levels of potential concern.

Potential hazards (HQs greater than 1) may occur for aquatic life and invertebrates in shallow ponds that have minimal water recharge and that may now, or in the future, be located in close proximity to the Facility. Potential aquatic life toxicity in lakes and ponds may reduce food abundance for higher trophic level organisms and thereby more broadly affect general ecosystem health. The river ecosystem may off-set any such reduced food abundance.

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ATTACHMENT C

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The ecological risk assessment uses the same water concentration calculations as the human health risk assessment. See Attachment B-2. Attachment E-2 has no page inserts.

ATTACHMENT E-3

FORAGE CONCENTRATION CALCULATIONS

ATTACHMENT E-4

DOSE AND RISK CALCULATIONS

ATTACHMENT F

ECOLOGICAL RISK ASSESSMENT CALCULATIONS

CUMULATIVE CONDITION

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SOIL CONCENTRATION CALCULATIONS

ATTACHMENT F-2

WATER CONCENTRATION CALCULATIONS

The ecological risk assessment uses the same water concentration calculations as the human health risk assessment. See Attachment C-2. Attachment F-2 has no page inserts.

ATTACHMENT F-3

FORAGE CONCENTRATION CALCULATIONS

ATTACHMENT F-4

DOSE AND RISK CALCULATIONS